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Geophysical Abstracts, 184-187 January-December 1961

G E O L O G I C A L S U R V E Y B U L L E T I N 1 1 4 6

*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1962

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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156-159, January-December 1954, Geological Survey Bulletin 1022.

160-163, January-December 1955, Geological Survey Bulletin 1033.

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Geophysical Abstracts 184 January-March 1961

By JAMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, and others

G E O L O G I C A L S U R V E Y B U L L E T I N 1 1 4 6 - A

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III

By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others

INTRODUCTION

Extent of Coverage

Geophysical Abstracts includes abstracts of technical papers and books on the physics of the solid earth, the application of physical methods and techniques to geologic problems, and geophysical exploration. The table of contents, which is alphabetically arranged, shows the material covered.

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memorandums) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

List of Journals

Lists of journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033-A) and subsequent issues through 175 (October-December 1958, Bulletin 1086-D) have been compiled into a single list, which may be obtained by writing to the U. S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 175. The following is an additional supplement that lists references cited in Geophysical Abstracts 184 that have not been listed previously.

Arizona Geol. Soc. Digest—Arizona Geological Society Digest. Tucson, Arizona.

Geog. Rundschau—Geographische Rundschau [Geographical Review]. Georg Westerman Verlag. Braunschweig, German Federal Republic.

Geol. Gesell. Ber.—Berichte der Geologischen Gesellschaft in der deutschen demokratischen Republik für das gesamtgebiet der geologischen Wissenschaften [Reports of the geological society of the German Democratic Republic for the entire field of geological sciences]. Berlin, German Democratic Republic.

Hokkaido Univ. Faculty Sci. Jour.—Journal of the Faculty of Science, Hokkaido University. Sapporo, Japan.

Impact—Impact of science on society. United Nations Educational, Scientific and Cultural Organization. Paris, France.

Nat. Sci. and Mus.—Natural Science and Museums. National Science Museum. Tokyo, Japan.

Problemy Geokhimii—Problemy Geokhimii [Problems of Geochemistry]. L'vovskiy Gosudarstvennyy Universitet. L'vov, U. S. S. R.

Research Appl. Industry—Research Applied in Industry. Butterworths Scientific Publications. London, England.

Royal Geol. Soc. Cornwall Trans.—Transactions of the Royal Geological Society of Cornwall. Penzance, England.

Univ. Indonesia, Inst. Technology Bandung, Dept. Geology Contr.—Contributions from the Department of Geology, Institute of Technology Bandung, University of Indonesia. Bandung, Indonesia.

Yorkshire Geol. Soc. Proc.—Proceedings of the Yorkshire Geological Society. Hull, England.

Form of Citation

The abbreviations of journal titles used are those used in the U. S. Geological Survey publications and in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board of Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991-A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

Abstracters

Abstracts in this issue have been prepared by H. Faul, A. J. Shneiderov, and J. H. Swartz, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstracter following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 184-1. Wetherill, G[eorge] W. Age of the base of the Cambrian: *Nature*, v. 187, no. 4731, p. 34-35, 1960.
Holmes, Arthur. Age of the base of the Cambrian: *ibid*, p. 35-36, 1960.

Wetherill draws attention to some problems existing in the determination of the base of the Cambrian and shows that the data used by Holmes in establishing the revised date of 600 ± 20 million years, based on absite from pegmatites overlain by the Adelaide series in South Australia and on uraninite from Katanga do not yield a firm maximum age for the base of even the Middle Cambrian.

Holmes claims that Wetherill overrates some of the difficulties and exaggerates their geochronological consequences. The provisionally adopted figure of 600 ± 20 million years was a reasonable estimate in the light of evidence then available; it should not be regarded as established fact. Disagreement over interpretation of inconclusive data is of minor significance in view of age determinations on Lower Cambrian and Upper Cambrian glauconites of some other areas. One particularly valuable set of results is from the relatively undisturbed Russian platform—recalculated using decay constants that correspond with American and British practice, the value obtained for the Lower Cambrian is 566×10^6 yr and that for the Upper Sinian, separated from it by only a slight unconformity, is $692-701 \times 10^6$ yr. — D. B. V.

- 184-2. Clark, David L. U-Pb age determination and Upper Devonian biostratigraphy: *Geol. Soc. America Bull.*, v. 72, no. 1, p. 163-165, 1961.

Physical and biological evidence suggests that the minimum age of the Devonian-Mississippian boundary is about 335-340 million years. The figure of 350 million years of Cobb and Kulp (see *Geophys. Abs.* 181-28) is not a minimum but a maximum figure for this boundary. As 10-15 million years is within the range of reliability of the uranium-lead sample, this does not radically change the significance of the 350-million-year date; it simply emphasizes the importance of biostratigraphic understanding in the application of geochemical dates to the stratigraphic section. — D. B. V.

- 184-3. Tilton, G[eorge] R., and Davis, G. L. Geochronology, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 190-216, 1959.

The accomplishments of geochronology with respect to geological problems are reviewed. The reliability of the isotopic methods of age determination is evaluated briefly, and some new investigations and their application are discussed. Particular attention is being given to tracing orogenic belts in time and space in order to evaluate the role of orogenies in the development of the continents. It is concluded that confidence in age determinations is justified when two different methods give the same result for a mineral or mineral assemblage; it is most satisfactory when agreement exists between the mica and the uranium-lead ages. For granites this agreement indicates time of crystallization of the granite as a whole. The frequent occurrence of unexpected results indicates that our knowledge of many phenomena concerning rocks and minerals needs improvement. — V. S. N.

- 184-4. Gilletti, B[runo] J., and Lambert, R. St. J. Radioisotopes in the dating of geological and archaeological events: *Research Appl. Industry*, v. 12, no. 10/11, p. 368-373, 1959.

Methods for determining the age of geological and archeological events using radio isotopes are reviewed. The C^{14} method as applied to events up to 70,000 yr is described. The U-Th-Pb, K-Ar, and Rb-Sr decay schemes are discussed in terms of their use in dating geological events that are millions or thousands of millions of years old. The apparent ages of various parts of the crust are shown on a world map. — J. W. C.

- Farley, Thomas A. Half-period of Th^{232} . See *Geophys. Abs.* 184-513.

- 184-5. Sobotovich, E. V. Vystupleniye E. V. Sobotovicha [Address of E. V. Sobotovich]: *Akad. Nauk SSSR, Dom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 7th sess., p. 88-90, 1958 (1960).

A method for determining primary and radiogenic lead is proposed on the assumption that the magma contained lead in a single form during differentiation and solidification and that the lead remained isotopically identical in all the rock-making minerals, provided the time of solidification was small compared with the age of the rock. The following system of equations is proposed: $a + \gamma x = d$; $a' + x = d'$; and $a/a' = \lambda$, where d and d' are the measured quantities of any lead isotope except Pb^{204} in two minerals; a is the quantity of primary lead in the first mineral, x is the radiogenic isotope admixture, a' and x' are the same quantities in the second mineral, λ is the ratio of Pb^{204} in the first to that in the second mineral, and γ is the ratio of the quantity of radioactive element in the first mineral to that in the second. The primary isotopes sought in the first and the second minerals are then given by the equations: $a' = (d - \gamma d') / (\lambda - \gamma)$, and $a = \lambda a'$. — A. J. S.

- 184-6. Norbutt, K. I., Bepalova, I. D., Laputina, I. P., Kardakov, K. A., and Samoylov, G. P. Izotopicheskiy sostav rudnogo svintsa i vozrast mineralov, soderzhashchikh U, Th, i Pb po mass-spektrometricheskimi rentgeno-spektral'nym dannym [Isotopic composition of lead ore and the age of minerals containing U, Th, and Pb according to mass spectrometry and X-ray-spectrum methods]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 7th sess., p. 250-265, 1958 (1960).

The X-ray-spectrum method of absolute age determination of uranium and thorium minerals can be used successfully for monazite and uraninite, but cannot be applied to pitchblende, brannerite, and samarskite unless mass spectroscopic analysis of the lead is made independently. The absolute ages of a large group of minerals from various regions of the U. S. S. R. obtained by the X-ray spectrum and of some minerals by the lead-isotope method are given. — A. J. S.

- 184-7. Fanale, Fraser, and Kulp, J. L[aurence]. Helium in limestone and marble: *Am. Mineralogist*, v. 46, no. 1-2, p. 155-167, 1961.

The helium and uranium contents of a number of specimens of marble, Iceland spar, and fossil shell of known age have been determined. The gross helium retentivity in calcite is small and highly variable, indicating that most of the uranium is external to the lattice. An excess of helium in the marbles over the amount calculated from the age and alpha activity is attributed to fluid inclusions containing gases present in the metamorphic environment. It is concluded that the helium method is not a practical geochronometer for carbonates. — D. B. V.

- 184-8. Hurley, P[atrack] M., Cormier, R. F., Hower, J., Fairbairn, H[arold] W., and Pinson, W[illiam] H., Jr. Reliability of glauconite for age measurement by K-Ar and Rb-Sr methods: *Am. Assoc. Petroleum Geologists Bull.*, v. 44, no. 11, p. 1793-1808, 1960.

Age measurements on 38 glauconites by the K-Ar and Rb-Sr methods show a consistent variation with geologic age with a small scatter. The results appear to fall 10-20 percent short of ages measured on micas of associated dated igneous rocks. The K-Ar and Rb-Sr ages are closely concordant in the majority of samples.

It is concluded that there is some consistent mechanism acting to lower the age of glauconites. This mechanism may be related to diagenetic modifications in the structure of the glauconitic material, and this process may continue with time. Superimposed on this rather uniform process is a variability due in part to occluded detrital grains of muscovite, or to argon loss by diffusion in samples deeply buried in folded sedimentary sections.

The factors influencing glauconite ages may be universally constant enough to permit the use of an empirical glauconite time scale for limited purposes. — D. B. V.

- 184-9. Polevaya, N. I., Kazakov, G. A., and Murina, G. A. Glaukonity kak indikator geologicheskogo vremeni [Glauconites as an indicator of geologic time]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 7th sess., p. 419-429, 1958 (1960).

Results of argon age determinations on 40 glauconite-bearing rocks from the U. S. S. R. and Czechoslovakia are reported. The various methods of separation of glauconite into monomineralic fractions have different effects on the argon and potassium in the sample. Mechanical and magnetic means are preferred rather than use of heavy liquids that contain potassium or thallium. — A. J. S.

- 184-10. Amirkhanov, Kh. I., Brandt, S. B., Bartnitskiy, Ye. N., Gurchich, V. S., and Gasanov, S. A. Kvoprosu o sokhrannosti radiogennogo argona v glaukonitakh [Problem of retention of radiogenic argon in

glauconites]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 202-207, 1957 (1960).

This is the same as the paper previously published in Akad. Nauk SSSR Doklady, v. 118, no. 2, p. 328-330, 1958 (see Geophys. Abs. 172-12). — J. W. C.

- 184-11. Damon, Paul E., Hedge, Carl E., Taylor, Omer J., and Halva, Carroll. Radiometric determination of potassium in silicates: Arizona Geol. Soc. Digest, v. 3, p. 75-80, 1960.

A radiometric method for potassium analysis which requires no chemical preparation is described. The method, developed at Columbia University and further tested in the geochronology laboratories of the University of Arizona, involves alpha- and beta-counting of a powdered sample. The beta count, which may be taken with or without a 5 mil aluminum absorber to eliminate soft beta particles from Rb^{87} , is reduced by an empirical correction for the betas resulting from the uranium and thorium series. The alpha count, due only to the uranium and thorium series, determines the magnitude of this correction. The resulting beta count is compared with a standard sample of potassium to determine the potassium content.

The average difference of the radiometric values from other methods for samples containing > 1.5 percent potassium is approximately 2.7 percent; this is about equal to the average standard deviation computed from statistical considerations. The error rises rapidly for samples containing < 1.5 percent. It is concluded that the alpha-beta radiometric method for determining potassium is very reliable and is apparently as precise as the methods used for comparison. — V. S. N.

- 184-12. Vorsin, A. N. Radiochastotnyy mass-spektrometr dlya opredeleniya absolyutnogo vozrasta gornykh porod pokaliy-argonovomu metodu [Radiofrequency mass spectrometer for determination of absolute age of rocks by the potassium-argon method]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 265-267, 1957 (1960).

A new radiofrequency mass spectrometer of the Bennett type for determination of argon isotopes in rocks is described. The resolving power is about 30. Another such instrument with a resolving power of 100 is being designed. — A. J. S.

- 184-13. Amirkhanov, Kh. I., Brandt, S. B., Ivanov, V. S., and Truzhnikov, M. S. O metodike mass-spektrometricheskogo opredeleniya radiogennogo argona v gornykh porodakh [On the method of mass-spectroscopic determination of radiogenic argon in rocks]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 287-293, 1957 (1960).

Experience in using the MC-2M mass spectrometer for age measurements on sedimentary and igneous rocks by the potassium-argon method is discussed. The spectrometer contains more than 100 electronic tubes and a high vacuum apparatus. Damage that occurred during the 3-year operation (more than 1,000 determinations) of MC-2M is analyzed and improvements are suggested. The accuracy of the method ranges within 6-12 percent error depending on the age of the rock. — A. J. S.

- 184-14. Krylov, A. Ya., and Silin, Yu. I. Znachenie argon-kaliyevogo otnosheniya v osadochnykh i metamorficheskikh porodakh [The meaning of the argon-potassium ratio in sedimentary and metamorphic rocks]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 292-311, 1958 (1960).

This is virtually the same as the paper published in Akad. Nauk SSSR, Izv. Ser. Geol., no. 1, p. 56-66, 1960 (see Geophys. Abs. 182-12). — A. J. S.

- 184-15. Murina, G. A., and Sprintsson, V. D. K voprosu o migratsionnoy sposobnosti kaliya i argona [Problem of migratory capability of potassium and argon]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 343-349, 1958 (1960).

Migration of potassium and argon in feldspars and micas was studied. The Ar^{40} content in the minerals investigated decreased at a slower rate than that of K^{40} . The $\text{Ar}^{40}/\text{K}^{40}$ ratio was found to change by 2.5-3.0 percent in micas, and by 8-30 percent in feldspars. — A. J. S.

- 184-16. Amirkhanov, Kh. I., Brandt, S. B., Bartnitskiy, Ye. N., Gasanov, S. A., and Gurvich, V. S. O mekhanizme poter' radiogennogo argona v slyudakh [On the loss mechanism of radiogenic argon in micas]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 350-356, 1958 (1960).

This is the same as the paper previously published in Akad. Nauk SSSR, Izv. Ser. Geol., no. 3, p. 104-107, 1959 (see Geophys. Abs. 177-15). — A. J. S.

- 184-17. Amirkhanov, Kh. I., Brandt, S. B., and Bartnitskiy, Ye. N. K opredeleniyu absolyutnogo vozrasta kaliyevykh polevykh shpatov argonovym metodom [Determination of the absolute age of potassium feldspars by the argon method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 357-360, 1958 (1960).

This is the same as the paper previously published in Akad. Nauk SSSR, Izv. Ser. Geol., no. 11, p. 110-112, 1958 (see Geophys. Abs. 176-10). — A. J. S.

- 184-18. Rubinshteyn, M. M. K voprosu poter' argona kaliyevymi polevymi shpatami i o geologicheskoy znachenii etogo metoda [On the problem of argon loss in potassium feldspars and on the geological significance of this phenomenon]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 361-369, 1958 (1960).

The problem of loss of Ar and K by feldspars during geologic time, and the variation of such losses in individual rocks is discussed and analyzed. It was established by several investigators that such losses of Ar and K in feldspar result in an apparent age that is 10-40 percent younger than that of associated micas determined from the $\text{Ar}^{40}/\text{K}^{40}$ ratio, and that the degree of such a change has little or no correlation with the absolute age of the rock investigated. — A. J. S.

- 184-19. Shukolyukov, Yu. A. Nomogramma i vychislitel'naya lineyka dlya rascheta vozrasta gornykh porod i mineralov po dannym argonovogo metoda [A nomogram and a slide rule for age computation of rocks and minerals according to data of the argon method]: Vses. Nauchno-Issled. Geol. Inst. Inf. Sbornik, v. 1, p. 142-145, 1955.

A special nomogram and slide rule for mathematical treatment of experimental data of the argon method are described and discussed. Both nomogram and slide rule give the absolute age of the sample within 2 percent error. Less than one minute is required to make the calculation. — A. J. S.

- 184-20. Polevaya, N. I., Titov, N. Ye., and Sprintsson, V. D. Opyt primeneniya kal'tsiyevogo metoda dlya opredeleniya absolyutnogo vozrasta sil'vinov [Experiment in the use of the calcium method for the determination of the absolute age of sylvites]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 411-418, 1958 (1960).

This is the same as the paper previously published in *Geokhimiya*, no. 8, p. 718-726, 1958 (see *Geophys. Abs.* 177-21). — J. W. C.

- 184-21. Mann, W. B., Seliger, H. H., Marlow, W. F., and Medlock, R. W. Redetermination of the national carbon-14 standard: U. S. Nat. Bur. Standards Tech. News Bull., v. 44, no. 11, p. 182-183, 1960.

The value of the national sodium carbonate-C¹⁴ standard has been revised to 1.250 ± 1.5 percent disintegrations per sec per g of solution as compared with the old value of 1.280 ± 10 percent disintegrations per sec per ml of solution. The redetermined value is useful to research in chemical, biochemical, and industrial processes as well as in geological and archeological dating. — V. S. N.

- 184-22. Libby, W[illard] F. Radiocarbon dating: *Science*, v. 133, no. 3453, p. 621-629, 1961.

This is a review of the radiocarbon dating method. The formation of radiocarbon in the atmosphere, and counting and dating techniques are described. A curve of radiocarbon content versus age for samples of known age is presented. Prior to 1870 the radiocarbon content of living matter appears to have varied by only 1 percent or less. From 1870 to 1954 carbon dioxide from combustion of fossil fuels diluted the biosphere and reduced the radiocarbon content; the trend was reversed when atomic explosions began to introduce carbon-14 into the atmosphere. These recent perturbations are of no great concern for present dating work but could possibly create difficulties in the future, if the method continues to be used.

The important date of the last glacial maximum is now well established as $11,400 \pm 200$ yr ago. The uses of radiocarbon dating in geology, oceanography, meteorology, and particularly in archeology, and the accuracy of the results, are discussed briefly. — D. B. V.

- 184-23. de Vries, Hessel. Measurement and use of natural radiocarbon, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 169-189, 1959.

Recent improvements in methods of radiocarbon dating techniques are described, highlights of some older chronology in North America and Europe

(early Wisconsin and early Würm, respectively) are reviewed, and some new measurements of the variation of radiocarbon with time and location on earth are discussed. — V. S. N.

- 184-24. Bolin, Bert, and Eriksson, Erik. Changes in the carbon dioxide content of the atmosphere and sea due to fossil fuel combustion, in *The atmosphere and the sea in motion* (Rossby memorial volume): New York and Cambridge, Rockefeller Inst. Press and Oxford Univ. Press, p. 130-142, 1959; also in Woods Hole Oceanographic Inst. Collected Repr. 1959, Contr. no. 1025, 12 p., 1960.

The dissociation equilibrium of carbon dioxide in the sea is discussed with particular emphasis on the buffering effect of sea water when changes of the partial pressure of CO_2 in the gas phase take place. The results are used in a study of the changes of the carbon dioxide content of the atmosphere and the sea that occur as a result of release of CO_2 to the atmosphere by fossil fuel combustion. The 10 percent increase of the CO_2 content of the atmosphere reported by Callendar may be compatible with a Suess effect of only a few percent. Because of the small buffering effect of the sea, the biosphere on land may play a more important role for changes actually occurring in the atmosphere due to release of CO_2 by combustion than previously believed. — V. S. N.

- 184-25. Tilton, G[eorge] R., Wetherill, G[eorge] W., Davis, G. L., and Bass, M. N. 1000-million-year-old minerals from the eastern United States and Canada: *Jour. Geophys. Research*, v. 65, no. 12, p. 4173-4179, 1960.

Measurements on muscovite, biotite, microcline, uraninite, and zircon by the K-Ar, Rb-Sr, and lead isotope methods give ages ranging from 900 to 1,150 million years for rocks in Ontario, along the Appalachians from New York to North Carolina, and beneath the sedimentary cover in Michigan, Ohio, and West Virginia. The whole region is believed to be part of a belt, roughly parallel to the more recent Appalachian orogenic belt, in which igneous intrusion and metamorphism accompanied a major orogeny $1,000 \times 10^6$ yr ago. — D. B. V.

- 184-26. Tilton, G[eorge] R., Davis, G. L., Wetherill, G[eorge] W., Aldrich, L. T[homas], and Jäger, Emilie. The ages of rocks and minerals: *Carnegie Inst. Washington Year Book* 58, July 1, 1958-June 30, 1959, p. 170-178, 1959; reprinted in *Carnegie Inst. Washington Geophysical Lab. Ann. Rept. of Director for 1958-59, 1959*.

The mineral age measurements program of the Geophysical Laboratory is carried out in cooperation with the Department of Terrestrial Magnetism. The ages reported here for the Maryland Piedmont and the Southern Appalachians and for the pegmatites and granites of the Cutler batholith, Cutler, Ontario, are approximately the same as those reported in the Annual Report of the Director for 1958-59, Department of Terrestrial Magnetism (see *Geophys. Abs.* 184-27).

A report is also made of a preliminary study of the age relationships of some Alpine rocks. Indications are that in favorable cases the young age of the Alps will not prevent the application of the Rb/Sr and K/A methods to rocks of Alpine age. — V. S. N.

- 184-27. Aldrich, L. T[homas], Wetherill, G[eorge] W., Bass, M[anuel] N., Compston, W., Davis, G. L., and Tilton, G[eorge] R. Mineral age measurements: Carnegie Inst. Washington Year Book 58, July 1, 1958-June 30, 1959, p. 237-250, 1959; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1958-59, 1959.

Age determinations directed toward the location in time and space of the great Precambrian mountain chains or orogenic belts are reported for the following areas: the Appalachian orogenic belt from New York to North Carolina and Tennessee; the southern Canadian shield in Ontario, Michigan, and Wisconsin; igneous rocks of southern Missouri and the Arbuckle and Wichita Mountains of Oklahoma; Death Valley, Calif.; and other countries including Finland, Saudi Arabia, Australia, and Venezuela. — V. S. N.

- 184-28. Bass, Manuel N. Grenville boundary in Ohio: Jour. Geology, v. 68, no. 6, p. 673-677, 1960.

Basement rocks penetrated by deep wells in Ohio can be sharply divided by a boundary trending slightly west of north into high grade metamorphic rocks on the east and unmetamorphosed igneous and sedimentary rocks on the west. Micas from the metamorphics give rubidium-strontium ages between 900 and 1,000 million years, indicating they are part of the Grenville orogenic belt. The sharp lithologic contrast across the boundary suggests that it is truly the Grenville boundary. The unmetamorphosed igneous rocks west of the boundary are similar to those from basement wells in Illinois and Indiana and from outcrops in southern Wisconsin, the St. Francis Mountains, and the Arbuckle Mountains. Micas and feldspars from the outcropping rocks give rubidium-strontium ages of 1,350-1,450 million years. The writer thinks that all these rocks west of the boundary comprise a nonorogenic igneous province, and therefore the rocks west of the boundary in Ohio will prove to be older than the rocks of the Grenville orogenic belt. — Author's abstract

- 184-29. Adams, J[ohn] A. S., Osmond, J. K., Edwards, G[eorge], and Henle, W. Absolute dating of the Middle Ordovician: Nature, v. 188, no. 4751, p. 636-638, 1960.

Zircons from four Middle Ordovician bentonites of well established stratigraphic position from Tennessee have been dated on the basis of isotope measurements of the lead; the uranium and lead concentrations were determined by isotopic dilution. Using decay constants of $1.537 \times 10^{-10} \text{ yr}^{-1}$ for U^{238} and $9.72 \times 10^{-10} \text{ yr}^{-1}$ for U^{235} , the $\text{U}^{238}/\text{Pb}^{206}$ and $\text{U}^{235}/\text{Pb}^{207}$ ages were calculated; results are tabulated. Previously unpublished determinations by Faul and Tilton on zircon and biotite from an Alabama bentonite of similar age are also reported; in all respects their measurements are corroborative. The average of the consistent $\text{U}^{238}/\text{Pb}^{206}$ ages, $447 \pm 10 \times 10^6 \text{ yr}$, is considered to be most reliable for Middle Ordovician time in Tennessee and Alabama. — D. B. V.

- 184-30. McFarlan, E., Jr. Radiocarbon dating of Late Quaternary deposits, south Louisiana: Geol. Soc. America Bull., v. 72, no. 1, p. 129-158, 1961.
Broecker, Wallace [S.]. A discussion of the above paper: *ibid*, p. 159-161, 1961.

A complete cycle of sea level fluctuation associated with major changes in continental glaciation since the beginning of the last glacial stage, recorded in the Late Quaternary deposits of southern and offshore Louisiana, has been dated by radiocarbon analysis of 122 surface and subsurface samples. The eustatic curve obtained implies that the last major glacial stage reached its maximum and had begun to retreat before 35,000 yr ago, and that the final retreat began 18,500 yr ago and ended 5,000 yr ago. No general agreement exists between the eustatic data and other estimates on the age of maximum glaciation and beginning of ice retreat.

Broecker states that McFarlan's conclusions as to the time of the last glacial maximum and retreat do not seem justified on the basis of the data presented. An acceleration in sea level rise just prior to 11,000 yr ago is not ruled out. — D. B. V.

- 184-31. Hayden, Richard J., and Wehrenberg, John P. $A^{40}\text{-K}^{40}$ dating of igneous and metamorphic rock of western Montana: Jour. Geology, v. 68, no. 1, p. 94-97, 1960.

Potassium-argon age determinations on samples of biotite, feldspar, and hornblende from igneous and metamorphic rocks in western Montana are reported in a table. — V. S. N.

- 184-32. Hester, Jim J. Late Pleistocene extinction and radiocarbon dating: Am. Antiquity, v. 26, no. 1, p. 58-77, 1960.

All radiocarbon dates from North America that are associated with extinct Late Pleistocene mammals, those from levels stratigraphically later than levels with extinct forms, and those associated with recent fauna are tabulated alphabetically by site. Dates considered invalid are tabulated but are not used in formulating conclusions.

Conclusions are then drawn concerning the time range of certain herding mammals, the mammoth, the mastodon, the super bison, and the ground sloth. Partial contemporaneity of the Clovis elephant hunters and the Folsom bison hunters is indicated. — D. B. V.

- 184-33. Smith, D. G. W., Baadsgaard, H., Folinsbee, R. E., and Lipson, J[oseph]. K/Ar age of Lower Devonian bentonites of Gaspé, Quebec, Canada: Geol. Soc. America Bull., v. 72, no. 1, p. 171-173, 1961.

Seven samples of Lower Devonian bentonites from the Gaspé Peninsula were dated by the potassium-argon method, using the constants $\lambda_e = 0.589 \times 10^{-10}/\text{yr}$ and $\lambda_\beta = 4.76 \times 10^{-10}/\text{yr}$. The suggested age of $385 \pm 15 \times 10^6$ yr is in accord with Holmes' revised time scale and is supported by a number of dates obtained by Hurley and others (1958) for intrusions cutting Lower Devonian sediments in New England and Acadian areas. — D. B. V.

- 184-34. Semenenko, N. P. Voprosy geokhronologii dokembriya Afriki [Problems of geochronology of the Precambrian of Africa]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 139-145, 1957 (1960).

A review of geochronological determinations of African Precambrian rocks is given. The absolute ages obtained by the uranium-thorium-lead, lead isotope, rubidium-strontium, and to some extent, potassium-argon methods on

uraninite, monazite, samarskite, euxinite, betafite, pyrochlore, brannerite, columbite, and zircon from African Precambrian rocks are compared with Precambrian ages from the U. S. S. R. The Precambrian is subdivided into Precambrians IV (630-1,200 million years), III (1,200-1,850 million years), II (2,000-2,900 million years), and I (3,000-3,800 million years). — A. J. S.

- 184-35. Nicolaysen, L. O., de Villiers, J. W. L., Burger, A. J., and Strelow, F. W. E. New measurements relating to the absolute age of the Transvaal system and of the Bushveld igneous complex: South Africa Geol. Soc. Trans. and Proc. for 1958, v. 61, p. 137-163, (1960).

Reliable data relative to the absolute age of the Transvaal system are crucial to the delineation of a quantitative time scale for South African stratigraphy. Since 1954 the following investigations have been carried out: rubidium-strontium age determinations on micas from four Bushveld igneous rocks; uranium-lead and thorium-lead age determinations on six monazites from Houtenbek 392, Moos River district; uranium-lead age determinations on three zircon concentrates from a granite near Ottensville, Central Bushveld; and a study of lead isotopic compositions of galenas deposited within sediments of the Transvaal system. It is concluded that an age of $1,950 \pm 150$ million years can be assigned to the intrusion of the Bushveld igneous complex and, therefore, the Transvaal system was deposited at a time greater than $1,950 \pm 150$ million years ago. It appears that existing chronologies of South African strata need revision. — V. S. N.

- 184-36. Schreiner, G. D. L., and Niekerk, C. B. van. The age of a Pilansberg dyke from the central Witwatersrand: South Africa Geol. Soc. Trans. and Proc. for 1958, v. 61, p. 197-203, (1960).

The age of the Robinson dike, one of a system of dikes radiating in a south to southeast direction from the Pilansberg intrusive in the Transvaal, has been determined by the rubidium-strontium method. It is concluded that the age determined, $1,290 \pm 180$ million years, may be extended to the rest of the dike system and, therefore, to the Pilansberg intrusive itself. This means that the Waterberg system is older than 1,300 million years and, if its correlation with the Matsap is valid, rules out the possibility of the correlation of the latter with the Table Mountain sandstone (see also Geophys. Abs. 173-11). — V. S. N.

- 184-37. Durand, Georges [L.], and Lay, Claude. Détermination de l'âge de quelques galènes de la vallée du Niari (Moyen Congo) [Détermination of the age of some galenas from the Niari valley (Moyen Congo)]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 5, p. 750-751, 1960.

The lead isotope ages of 6 galenas and 1 cerussite from the Niari valley in Moyen Congo are tabulated. The techniques and material used were described in an earlier note (see Geophys. Abs. 183-27). Four of the galenas are apparently from the same Precambrian epoch ($630-650 \times 10^6$ yr), and the cerussite is slightly younger (580×10^6 yr); these values confirm Bigotte's conclusions (1959). A value of 510×10^6 yr for the N'Zala galena is explained by secondary mineralization, and a still lower value of 420×10^6 yr for the Djen-guillé galena is explained by the presence of radiogenic lead from uranium mineralization in the vicinity. — D. B. V.

- 184-38. Galanopoulos, A. G. Zur Bestimmung des Alters der Santorin-Kaldera [Determination of the age of the Santorin caldera (with English abstract)]: *Annales Geol. des Pays Helléniques*, 1st ser., v. 9, p. 184-185, 1958.

This is virtually the same as the paper published in *Neues Jahrb. Geologie u. Paläontologie Monatsh. Jahrg.* 1957, Heft 9, p. 419-420 (see *Geophys. Abs.* 171-17). — J. W. C.

- 184-39. Šmejkal, Václav. Absolutní stáří některých granitoidů a metamorfítů Českého masivu stanovené kalium-argonovou metodou [Absolute age of some granitic and metamorphic rocks of the Czech massif determined by the potassium-argon method (with Russian summary)]: (Czechoslovakia) *Ústřed. Ústav. Geol. Věstník*, v. 35, no. 6, p. 441-449, 1960.

The potassium-argon ages of 35 granitic and metamorphic rocks from different parts of Czechoslovakia have been determined using the decay constants $\lambda_K = 0.557 \times 10^{-10} \text{yr}^{-1}$ and $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$; results are tabulated, along with 10 determinations made in the U. S. S. R. recalculated using the same constants. Two intrusive cycles are indicated, corresponding closely with those established by Vinogradov and others for Saxony (see *Geophys. Abs.* 182-44). A young Variscan cycle, to which the tin, tungsten, and molybdenum mineralization of the Erzgebirge is related, occurred 260 million years ago in Early Permian or at the Stephanian-Permian boundary according to Kulp's time scale. An older Variscan cycle, in the Erzgebirge and in the plutons of central Bohemia, apparently occurred about 360-370 million years ago in Early Devonian; however, a correction for nonradiogenic argon probably would place this cycle at the Devonian-Carboniferous boundary, or somewhat younger. — D. B. V.

- 184-40. Kantor, Ján. Príspevok k poznaniu Veporidných granitov podľa A/K⁴⁰ metódy [Contribution to the understanding of the Veporide granites by the K/Ar method (with German summary)]: *Slovenská Akad. Vied Geol. Práce*, v. 16, p. 5-10, 1959.

The Hrončok granite is part of the highly metamorphosed belt of the west central Carpathians, the so-called Tatra Veporides of unknown stratigraphic age. Volumetric potassium-argon age determinations (without correction for atmospheric argon contamination) give 110 million years for potassium feldspar and 115 million years for biotite, calculated with the K-capture and beta-decay time constants of $6.02 \times 10^{-11} \text{yr}^{-1}$ and $49 \times 10^{-11} \text{yr}^{-1}$, respectively. — H. F.

- 184-41. Kantor, Ján. Kriedové orogenetické procesy v svelte geochronologického výskumu Veporidného kryštalinika (Kohútске pásmo) [Cretaceous orogenic processes in the light of geochronological studies of the Veporide crystalline rocks of the Kohút belt (with German and English summaries)]: *Slovenská Akad. Vied Geol. Práce*, v. 19, p. 5-26, 1960.

Age measurements on biotite concentrates from five Veporide crystalline rocks from central Slovakia give 75-107 million years by the potassium-argon method (no air-argon correction), using the K-capture and beta-decay constants of $6.02 \times 10^{-11} \text{yr}^{-1}$ and $49 \times 10^{-11} \text{yr}^{-1}$, respectively. Glauconite from

an Albian limestone near Wielka Rówien in the Polish High Tatra Mountains gives 88 million years. Location of the samples is shown on a geologic sketch map of Slovakia. It is concluded that the ages indicate an intensive orogeny 75 to 80 million years ago, belonging to the "sub-Hercynian Alpine phase." The later Laramide orogeny apparently was of much lower intensity in the Veporides. — H. F.

- 184-42. Kantor, Ján. Príspevok ku geochronológii nízkotatranských granitoidov [Geochronology of the granitic rocks of the Low Tatra]: Slovenská Akad. Vied Geol. Práce, no. 55, p. 159-169, 1959.

Ages of the Dunbier and Prašivá granites from the central massif of the Low Tatra in central Slovakia, heretofore usually regarded as Precambrian, were measured by the volumetric potassium-argon method on biotite, muscovite, and feldspar. Major-constituent chemical and trace-element spectrochemical analyses are reported for most samples. Six of the nine samples, uncorrected for atmospheric argon contamination, give ages from 270 to 360 million years with feldspar giving the lowest ages. Three mica samples analyzed in the laboratory of I. E. Starik (Leningrad) with correction for atmospheric argon contamination give 300, 305, and 330 million years, respectively. All ages are computed with the decay constants for K-capture and beta-decay of $6.02 \times 10^{-11} \text{yr}^{-1}$ and $49 \times 10^{-11} \text{yr}^{-1}$, respectively. — H. F.

- 184-43. Vinogradov, A. P., Tugarinov, A. I., Zykov, S. I., and Stupnikova, N. I. O vozraste gornyx porod Aldanskogo shchita [On the age of the rocks of the Aldan shield (with English summary)]: Geokhimiya, no. 7, p. 563-569, 1960.

The results of 18 absolute age determinations on uranium-thorium minerals from the Aldan shield are tabulated. Ancient intrusives in the core of the shield are 2,200-2,700 million years old. Intensive volcanism in and around the periphery of the shield took place 1,140±50 and 650±50 million years ago. The effect of later Paleozoic and Mesozoic metamorphism is detected in some minerals in the form of a sharp decrease in Pb/U and Pb/Th age values. — D. B. V.

- 184-44. Semenenko, N. P., Burkser, Ye. S., and Ivantishin, M. N. Sra-vnitel'naya kharakteristika vozrasta gornyx porod ukrainskogo kristallicheskogo massiva [Comparative study of the age of rocks of the Ukrainian crystalline massif]: Akad. Nauk SSSR, Kom. O-predeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 5th sess., p. 86-110, 1958.

In an attempt to study the migration of radiogenic elements and the absolute age of Precambrian rocks, parallel age determinations were made on minerals from the same rocks by four different laboratories. Samples from seven localities in the Ukraine massif were investigated by the argon method (for biotite and feldspar) and by the lead method (for accessory minerals such as allanite, sphene, and monazite). The rubidium age was also determined for several micas. Results are given for each locality. A divergence in the absolute ages as determined by the different methods (1,200, 1,400, and 1,900 million years for the same specimen) leads to the conclusion that the age data obtained must be checked against rubidium-strontium data. — A. J. S.

- 184-45. Ovchinnikov, L. N., Shur, A. S., and Panova, M. V. Nekotoryye resul'taty primeneniya kaliy-argonovogo metoda dlya opredeleniya

absolyutnogo vozrasta mineralov i gornyykh porod Urala [Some results of application of the potassium-argon method for determination of the absolute age of minerals and rocks of the Urals]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 8-26, 1957 (1960).

The results of more than 50 age determinations made by the Urals branch of the Academy of Sciences, U. S. S. R., are reported, and the methods of calculation are discussed. (See also Geophys. Abs. 172-17.) — A. J. S.

- 184-46. Garris, M. A. Pervyye rezul'taty opredeleniya kaliy-argonovym metodom absolyutnogo vozrasta gornyykh porod vostochnoy okrainy Russkoy platformy i Yuzhnogo Urala [The first results of absolute age determinations of rocks in the eastern borderland of the Russian platform and southern Urals by the potassium-argon method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 27-39, 1957 (1960).

Age determinations are reported for rocks of the crystalline basement of the Bashkir A. S. S. R. recovered from deep drill holes. The granitic gneisses range in age from 1,380 to 1,620 million years, and the gabbro diabases from 1,010 to 1,140 million years. Pegmatites from the eastern flank of the Ural Mountains yield ages of 210-270 million years. — J. W. C.

- 184-47. Amirkhanov, Kh. I., and Magatayev, K. S. Ob itogakh ustanovleniya absolyutnogo geologicheskogo vozrasta osadochnykh obrazovaniy neftenosnoy provintsii Dagestana [On the results of establishing the absolute geological age of sedimentary deposits in the oil-bearing region of Dagestan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 48-53, 1957 (1960).

Age determinations on 26 glauconites from sediments of Silurian, Jurassic, Cretaceous, and Tertiary age of Dagestan are reported. (See also Geophys. Abs. 179-13). — J. W. C.

- 184-48. Polevaya, N. I., and Chernova, N. N. Vozrast porod Zabaykal'ya po dannym argonovogo metoda [Age of rocks of the Transbaikalian area according to data of the argon method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 69-82, 1957 (1960).

Absolute ages were determined for various igneous rocks of the Transbaikalian area. The intrusives of the Caledonian magmatic cycle were dated at 250-435 million years, the plutons of the Hercynian magmatic cycle at 205-235 million years, and the Jurassic intrusions at 110-155 million years. A group of effusive rocks was dated at 125-245 million years. — A. J. S.

- 184-49. Polevaya, N. I., Sprintson, V. D., and Chernova, N. N. Vozrast magmатических пород yuga Dal'nego Vostoka [Age of magmatic rocks of the south of the Far East]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 83-106, 1957 (1960).

Argon ages of igneous rocks of the southpart of the Far Eastern Region are reported. Silicic extrusive rocks yield ages of 30-105 million years. The ages of several Jurassic granitic intrusives of Sikhote-Alin were determined at 120-175 million years; the Meso-Cenozoic intrusives of north Sikhote-Alin and of the left bank area of the lower course of the Amur River, 70-120 million years; the intrusives of the tectonic zone of the Khor and Anyuy Rivers, 75-95 million years; the intrusive rocks of the lower Amur basin, 65-120 million years; the Paleozoic intrusives of Maloye Khingan, 180-365 million years; the Mesozoic intrusives of Maloye Khingan, 85-180 million years; the Varisian intrusive complex in the basin of the Zeya and Bureya Rivers, 140-265 million years; and the igneous rocks of the Kur-Umra region, 100-155 million years. Some of the argon ages do not agree with the geologic ages of the rocks. — A. J. S.

- 184-50. Afanas'yev, G. D. O primeneni kaly-argonovogo metoda dlya tsel'ey geologii v svete rezul'tatov issledovaniy gornyykh porod i mineralov Kavkaza [On application of the potassium-argon method for geological purposes in the light of results of investigations of rocks and minerals of the Caucasus]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 107-118, 1957 (1960).

The suitability of potassium-sodium feldspars for potassium-argon age determinations is discussed. On the basis of argon ages on muscovites, microclines, and other minerals in the Caucasus, and by comparing the argon ages with lead isotope ages, data that are in a satisfactory agreement with geologic ages are obtained. — A. J. S.

- 184-51. Komlev, L. V., Gerling, E. K., and Zhirov, K. K. O vozraste redkometal'noy granitnoy intrusii Akchatau po dannym geliyevogo metoda dlya monazitov [On the age of the rare-metal granite intrusion of Akchatau according to data of the helium method for monazites]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 129-132, 1957 (1960).

Utilization of monazites for helium age determinations is discussed. Three samples of monazite from the Akchatau granite were dated at 324 ± 16 , 272 ± 14 , and 275 million years; the average is 290 million years. These data were regarded with uncertainty. A later determination on an additional monazite from Akchatau, however, has yielded an age of 284 million years. — A. J. S.

- 184-52. Semenenko, N. P., Ivantishin, M. N., and Burkser, Ye. S. Osnovnyye dannyye po geokhronologii Ukrainskogo kristallicheskogo massiva [Basic data on the geochronology of the Ukrainian crystalline massif]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 146-166, 1957 (1960).

Detailed examination of the stratigraphy of the Ukrainian crystalline massif indicates that the oldest units studied have an age of 2,300-2,600 million years and more. The age of the main lower stage of folding of the massif is 1,950-2,150 million years; this is the Bug stage. The second structural stage is the Saksagan. It occupies the central part of the massif and has an age of 1,700-1,920 million years. The third structural stage is represented by the Volyn folding and has an age of 1,400-1,600 million years. Next follows a group of granites of the age group 1,150-1,250 million years. The final Precambrian cycle consists of granites of the age group 500-900 million years. — J. W. C.

- 184-53. Polovinkina, Yu. Ir., Polevaya, N. I., and Murina, G. A. Absolyutnyy vozrast granitov Ukrainy [Absolute age of granites of the Ukraine]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 167-181, 1957 (1960).

A number of granites and their pegmatites from the Ukrainian crystalline massif were dated by the potassium-argon method, and the results are compared with data obtained by other authors by the argon and lead methods. On the basis of this analysis the age of the Lower Archean plagioclase granites ranges from 1,890 to 2,000 million years. The highest age obtained for the Dnieper region amphibolites is 2,000-2,500 million years, but some determination on these same rocks gave a much lower value of 1,300 million years. The reason for such great divergence for the same rock is unknown. — A. J. S.

- 184-54. Komlev, L. V., Danilevich, S. I., Ivanova, K. S., Mikhalevskaya, A. D., Savonenkov, V. G., and Filippov, M. S. O vozraste geologicheskikh formatsii yugo-zapadnoy chasti Ukrainskogo dokembriya [Age of geologic formations of the southwest part of the Ukrainian Precambrian]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 182-192, 1957 (1960).

This is the same as the paper previously published in *Geokhimiya*, no. 7, p. 566-572, 1957 (see *Geophys. Abs.* 180-6). — J. W. C.

- 184-55. Krylov, A. Ya., Baranovskaya, N. V., and Silin, Yu. I. Primeniye argonovogo metoda opredeleniya vozrasta k resheniyu nekotorykh geologicheskikh voprosov [Application of the argon method of age determination to solution of some geological problems]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 208-213, 1957 (1960).

The potassium-argon method can be used for determination of the age of source material of detrital rocks, the age of metamorphism of pelitic rocks, and the age of formation of new potassium minerals during metamorphism. The ages of several Carboniferous sandstones of the northern Tien Shan proved to be on the same order as that of their parent granite. Schists and gneisses from the Malyy Kebin River region yielded ages from 370 to 430 million years, which correspond to the main Caledonian orogeny. The age of hornfels is either close to that of the granite with which it is in contact or is somewhat higher. — J. W. C.

- 184-56. Shcherbakov, D. I. Napravleniye rabot po opredeleniyu absolyutnogo vozrasta geologicheskikh formatsiy [Direction of research in determination of the absolute age of geologic formations]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 7-12, 1958 (1960).

The principal areas of geochronological research in the U.S.S.R. are as follows: 1) age correlation by residual isotopes or by natural radioactive elements in rocks; 2) absolute age of Precambrian formations; 3) absolute age of tectono-magmatic processes in the development of geosynclinal zones; 4) variations in absolute age of the minerals of igneous rocks; and 5) determination of metallogenic epochs from absolute ages of ore deposits. — A. J. S.

- 184-57. Polkanov, A. A., and Gerling, E. K. Problema absol'yutnogo vozrasta dokembriya Baltiyskogo shchita [The absolute age problem of the Precambrian Baltic shield]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 13-45, 1958 (1960).

The Precambrian geology of the Baltic shield is reviewed in detail on the basis of about 230 age determinations. An argon age of 6,000 million years has been determined for beryl from the Kola Peninsula, which finds a parallel in the 4,000-5,000 million years yielded by beryl from Beryl Mountain, N. H. (see Geophys. Abs. 172-16). Age data on Precambrian rocks from the Scandinavian Peninsula, Finland, Karelia, and the Kola Peninsula are given in extensive tables, which contain information on the orogens, the geographic locations of the rocks dated, the geologic formations, and the ages determined with the old and the new constants of K^{40} . — A. J. S.

- 184-58. Semenenko, N. P. Geokhronologiya v absol'yutnom letoschislenii i voprosy geologicheskoy istorii dokembriya [Geochronology in absolute age and the problem of Precambrian geologic history]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 48-78, 1958 (1960).

Absolute ages of Precambrian geologic formations of Europe, Siberia, North America, and Africa are reviewed on the basis of determinations of the last 10 years. The Precambrian of the Ukrainian crystalline massif is dated from 900 to 3,000 million years; that of the Baltic shield—from 880 to 3,500 million years; the Urals—from 400 to 2,350 million years; the Russian platform—566 to more than 1,740 million years; Siberia—250-1,900 million years; the Canadian shield—200-2,600 million years; and the African platform—630-3,800 million years. A geochronological chart is given in which the Precambrian is divided into 10 cycles of mineralization and orogenesis. — A. J. S.

- 184-59. Komlev, L. V., Danilevich, S. I., Ivanova, K. S., Kuchina, G. N., Savonenkov, V. G., and Filippov, M. S. Absol'yutnyy vozrast kirovogradskikh i trakhitoidnykh granitov ukrainskogo dokembriya po dannym svintsovo-izotopnogo i argonovogo metodov [Absolute age of Kirovograd and trachytoid granites of the Ukrainian Precambrian according to the lead isotope and the argon methods]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 91-111, 1958 (1960).

The porphyritic granites of the Kirovograd type in the Ukraine S. S. R. yield a lead isotope age of $1,970 \pm 60$ million years and an argon age of $1,960 \pm 50$ million years. The trachitoid red granites of this same region give a lead-isotope age of $1,900 \pm 30$ million years and an argon age of $1,930 \pm 50$ million years. The similarity in age and the geochemical data both indicate that these igneous rocks belong to a single comagmatic series. — J. W. C.

- 184-60. Komlev, L. V., Filippov, M. S., Danilevich, S. I., Ivanova, K. S., and Savonenkov, V. G. Absol'yutnyy vozrast monatsitov iz nekotorykh krasnykh applitoidnykh granitov i pegmatitov ukrainskogo dokembriya [Absolute age of monazites from some red aplitic granites and pegmatites of the Ukrainian Precambrian]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 112-122, 1958 (1960).

Age determinations are reported on 17 monazites from red aplitic granites and pegmatites of the Ukraine S. S. R. The lead isotope ages range from 1,500 to 2,100 million years and correspond to the time of formation of the principal magmatic complexes of the Ukrainian Precambrian. The absolute age of some granites of the area, determined by the argon method, is 1,700-1,800 million years. — A. J. S.

- 184-61. Komlev, L. V., Filippov, M. S., Danilevich, S. I., Ivanova, K. S., Kryukova, N. F., Kuchina, G. N., and Mikhalevskaya, A. D. Vozrastnyye dannyye argonovogo i svintsovoizotopnogo metodov dlya nekotorykh granitov i pegmatitov Srednego Pridneprov'ya [Age data of the argon and lead isotope methods for some granites and pegmatites of the middle Dnieper area]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 123-130, 1958 (1960).

This is virtually the same paper as previously published in *Geokhimiya*, no. 2, p. 110-115, 1959 (see *Geophys. Abs.* 179-15). — A. J. S.

- 184-62. Semenenko, N. P. Vystupeniye N. P. Semenenko [Address of N. P. Semenenko]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 131-134, 1958 (1960).

The absolute ages of Ukrainian Precambrian rocks determined by the Ukrainian Academy of Sciences and those presented by Komlev (see *Geophys. Abs.* 184-59, -60, -61) are summarized. On the basis of the uranium-thorium-lead method, the Ukrainian crystalline massif formed during the time between 3,000 and 1,100 million years ago. — A. J. S.

- 184-63. Zhiron, K. K., Artemov, Yu. M., Volobuyev, M. I., Zhirona, V. V., Knorre, K. G., Stupnikova, N. I., Sten'ko, V. A., Tikhonov, V. Ye., and Arakelyan, V. A. O vozraste Tarakskoy intruzii Yeniseyskogo kryazha [On the age of the Tarak intrusion of the Yenisei range]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 135-142, 1958 (1960).

The absolute ages of various geological units of the Yenisei range in Siberia are reported. The investigation consisted of dating by the lead, argon, and strontium methods, determination of the isotope composition of the lead, and study of the distribution of radioactive and other elements that could provide geochemical criteria for following changes that have occurred in the rocks. The lead method yielded ages of 570-2,030 million years, and the ages obtained on other samples by the argon method were found to be 170-1,200 million years. — A. J. S.

- 184-64. Ovchinnikov, L. N. Absolyutnyy vozrast rudnykh mestorozhdeniy Urala po dannym argonovogo metoda [Absolute age of ore deposits of the Urals according to data of the argon method]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 143-151, 1958 (1960).

The results of argon age determinations on Ural ore deposits are reported. In the Early Paleozoic stage of metallogenesis, chalcopyrite deposits are dated at 420-460 million years and the associated igneous rocks at 455 million years.

In the Middle Paleozoic stage the contact-metasomatic rocks, the chalcopryrite deposits, and the pegmatites are dated at 330-365, 305-375, and 310-340 million years, respectively. In the Late Paleozoic stage the contact metasomatic rocks, the chalcopryrite deposits, the gold ores, and the pegmatites were dated at 240-245, 240-265, 270, and 260-275 million years, respectively. — A. J. S.

- 184-65. Ovchinnikov, L. N., Shur, A. S., and Dunayev, V. A. Ob absolyutnom vozraste geologicheskikh obrazovaniy Urala [On the absolute age of geological formations of the Urals]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 152-164, 1958 (1960).

Argon ages of 46 igneous and metamorphic rocks of the Urals are reported. The Precambrian units are dated at 1,155-1,940 million years. The Early Paleozoic igneous rocks yield dates of 440-500 million years, and the Middle Paleozoic rocks give 280-390 million years. Metamorphic rocks related to copper-bearing areas are dated at 240-460 million years. The conglomerates between the Proterozoic and Cambrian formations give dates of 240-390 million years. — A. J. S.

- 184-66. Garris, M. A., Shanin, L. L., Ustyuzhanin, L. S., Dyadin, N. N., and Soldatenkov, S. S. Absolyutnyy vozrast granitoidov yuzhnogo Urala i Mugodzhar po dannym kaliy-argonovogo metoda [Absolute age of granites of the south Urals and Mugodzhar according to the potassium-argon method]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 166-187, 1958 (1960).

Age determinations on granitic intrusives of the south Urals and the Mugodzhar region in Bashkir A.S.S.R., are reported. Most of these determinations were made by the potassium-argon method on potassium feldspars; some were on muscovite. On a basis of 58 samples the Carboniferous granites were dated at 180-297 million years, and the Silurian granites at 335-345 million years. The Carboniferous metamorphic rocks, dated by the anorthoclase from the Mugodzhar augen gneiss at 212 ± 7 million years, were thus shown to belong to the Upper Carboniferous instead of to the Archean. — A. J. S.

- 184-67. Knorre, K. G., Studenikova, Z. V., and Lebedev, V. I. Opreddeniyu absolyutnogo vozrasta porod severnogo Kavkaza kaliy-argonovym metodom [Determination of absolute age of the rocks of the north Caucasus by the potassium-argon method]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 188-194, 1958 (1960).

On a basis of recent absolute age determinations four intrusive granite complexes of the north Caucasus are discussed. The granite of the main ridge is dated at 270-470 million years, the complex of northern (Paleozoic and Triassic) granites at 175-230 million years; the complex of Mesozoic granites at 80-150 million years, and the Cenozoic complex of granites at 15-50 million years. No Precambrian intrusive rocks were found. The youngest age, determined by the U^{238}/Pb^{206} ratio, yielded 20 million years, as compared with 15 million years obtained by the potassium-argon method. — A. J. S.

- 184-68. Komlev, L. V., Filippov, M. S., Danilevich, S. I., Kryukova, N. F., Kuchina, G. N., and Mikhalevskaya, A. D. Absolyutnyy vo-

zrast gruppy gertsinskikh granitnykh plutonov Tsentral'nogo Kazakhstana [Absolute age of the group of Hercynian granitic plutons of central Kazakhstan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 205-215, 1958 (1960).

Argon ages were determined for biotite from granites, and lead ages for monazites from granites and pegmatites; all from rare-metal intrusions of alaskitic granites of central Kazakh S.S.R. The argon ages range from 260 to 360 million years, and the lead ages from 248 to 292 million years. The ages obtained do not agree with the Holmes time scale for the Paleozoic if the rare-metal alaskitic granites are considered as Late Carboniferous and Permian. — A. J. S.

- 184-69. Komlev, L. V., Filippov, M. S., Danilevich, S. I., Kryukova, N. F., Kuchina, G. N., Mikhalevskaya, A. D., and Savonenkov, V. G. Vozrast granitnoy intruzii Bektau-Ata v Severnom Pribalkhashye (Tsentral'nyy Kazakhstan) [The age of the Bektau-Ata granite intrusion in the northern Balkhash region (central Kazakhstan)]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 216-232, 1958 (1960).

Argon dating of the Bektau-Ata granite indicates persuasively that this mass has the same age as the rare metal granite intrusions of central Kazakh S.S.R. (see Geophys. Abs. 184-68). The most reliable age for these granites using the new K^{40} constant lies in the interval 280-320 million years, and the average value is 295 ± 15 million years. The average value based on three isotope ratios and on total radiogenic lead is 295 ± 5 million years. — J. W. C.

- 184-70. Komlev, L. V., Filippov, M. S., Kuchina, G. N., and Kryukova, N. F. Absolyutnyy vozrast granitnykh intruziy Kokchetavskogo podnyatiya v Severnom Kazakhstane [Absolute age of granite intrusion of the Kokchetavok uplift in northern Kazakhstan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 233-240, 1959 (1960).

Potassium-argon ages are reported for the granites of the Zerendinskaya, Borovskaya, Zolotonoshenskaya, Konstantinovskaya, and Orlinogorskaya intrusions of the Kokchetavok anticlinorium in north Kazakh S.S.R.; the new K^{40} constant was used. An early group of granites and less silicic granitic rocks is dated at 400-480 million years, a middle group of granites at 350-380 million years, and a later group of leucocratic rare-metal granites at 260-300 million years. — A. J. S.

- 184-71. Semenova, T. P. Absolyutnyy vozrast intruzivnykh porod rayona Kendyktasskikh gor Kazakhstana po dannym argono-kaliyevogo metoda [Absolute age of intrusive rocks of Kendyktas mountains of Kazakhstan according to data of the argon-potassium method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 242-249, 1958 (1960).

Absolute age determinations were made on igneous rocks of the northwestern side of the Kendyktas mountains in the Kazakh S.S.R.; it was concluded that the various types represent a comagmatic series. The potassium-argon method was used to date 14 rock samples, 4 quartz-feldspar fractions, and 2 biotite fractions. Fifteen of these samples yielded reliable data. The ages range from 355 to 480 million years. — A. J. S.

- 184-72. Bagdasaryan, G. P. O vozraste nekotorykh intrusiy Armenii po dannym geologicheskikh issledovaniy i radiologicheskikh opredeleniy (argonovym metodom) [On the age of certain intrusions of Armenia according to geologic investigations and radiologic determinations (by the argon method)]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 266-273, 1958 (1960).

Problems of absolute age determinations in Armenia are discussed, and the dates on 45 samples of rocks and minerals from Armenian intrusions are reported. The $\text{Ar}^{40}/\text{K}^{40}$ ratio of the samples ranges from 0.93 to 4.6, corresponding to absolute ages of 28-131 million years. These results are in agreement with the geologic ages of the intrusions according to the Marble scale. — A. J. S.

- 184-73. Yordanov, N. Issledovaniya ortita v svyazi s opredeleniyem absolyutnogo geologicheskogo vozrasta plutonov Plany [Investigations of orthite in connection with the absolute geologic age determination of the Plana pluton]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 274-282, 1958 (1960).

The absolute age was determined for plutonic rocks by the helium, lead, and argon methods, and a systematic study was made of the suitability of allanite (orthite) for geochronology. The most probable absolute age of the Plana plutons is 80 million years. The emanating properties of allanite indicate its good capacity to preserve the products of nuclear transformations. Due to the crystal structure, however, lead can easily be lost by diffusion during metamorphic processes or acquired during hydrothermal activity. The ratios of Pb/U and Pb/Th in the interior of the allanite crystals investigated are different from those in the exterior portion; the interior parts of the crystals, therefore, are recommended for analysis. — A. J. S.

- 184-74. Krylov, A. Ya., Silin, Yu. I., and Lovtseyus, A. V. Argon-kaliyevoe otnosheniye v razlichnykh chastiyakh granitnykh intruziy [The argon-potassium ratio in different parts of granite intrusions]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 283-291, 1958 (1960).

A study was made to detect "excess argon"—the argon assimilated by a crystallizing magma to produce an exaggerated absolute age. $\text{Ar}^{40}/\text{K}^{40}$ analyses were performed on four single-phase intrusions of the central Tien Shan: Dzhetty-Oguz (16 samples), Sary-Bulak (14 samples), Sary-Maynak (10 samples), and Kok-Mayhak (8 samples); these yielded absolute ages of 300-390, 285-415, 340-385, and 240-330 million years, respectively. No "excess argon" caused by an exogene contact effect was established. — A. J. S.

- 184-75. Gerling, E. K., Yashchenko, M. L., Levskiy, L. K., and Ovchinnikova, G. V. Opredeleniye vozrasta nekotorykh slyud po rubidiy-strontsiyevonyy metody [Determination of the age of several micas by the rubidium-strontium method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 326-342, 1958 (1960).

Absolute age determinations on micas from Proterozoic and Archean rocks by the rubidium-strontium method are reported. Using the 1.39×10^{-11} per yr

β -decay constant of Rb^{87} (see Geophys. Abs. 167-231), several samples of mica from the Kola Peninsula, Siberia, and the Murmansk region were dated. The ages range from $2,600 \pm 200$ to $1,800 \pm 150$ million years for the Kola Peninsula and Murmansk micas, and 420 ± 55 million years for those from the Mamsk region in Siberia. These ages are in general agreement with $\text{Ar}^{40}/\text{K}^{40}$ determinations; however, the muscovite rocks from the Mamsk region are considered to belong geologically to the Upper Archean and Lower Proterozoic. — A. J. S.

- 184-76. Usenko, I. S., Bernads'ka, L. H., and Kotlovs'ka, F. I. Noví dani vyznachennya viky postproterozhoys'kykh absolyutnoho efuzhyvnykh porid [New data on the determination of the absolute age of post-Proterozoic effusive rocks]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 18, no. 5, p. 83-88, 1958.

The results of potassium-argon age determinations on post-Proterozoic effusive rocks from the Ukraine are presented. Three age groups can be distinguished. The oldest is represented by the traps of the southwest part of the Russian platform and by the diabases associated with salt domes in the Dnieper-Donets basin; the age of the former is $506-566 \times 10^6$ yr and that of the latter $500-570 \times 10^6$ yr; therefore, they are Rhipian-Early Cambrian. The second group is represented by the spilite-keratophyre formations which occur in boreholes in the Chernigov gravity anomaly; these are $353-393 \times 10^6$ yr old, or Ordovician-Silurian (Caledonian orogeny), although according to geologic evidence they should be Devonian. The third group includes the spilite-keratophyre formations of the southern Donbass, which are $270-320 \times 10^6$ yr old, or Devonian (Hercynian orogeny). — D. B. V.

- 184-77. Shcherbak, M. P. Pro stupin' nadiynosti okremykh kryteriyiv pry vyznachenni vikovykh vzayemovidnoshen' mizh crystalichnymy porodamy dokembriyu (verkiv'ya r. Tetereva) [On the degree of reliability of individual criteria in the determination of the age relations of Precambrian crystalline rocks (upper course of the Tetereva River)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 1, p. 68-73, 1960.

The last section of this paper deals with absolute dating of crystalline rocks in the region of the upper course of the Tetereva River. According to uranium-lead and thorium-lead measurements, the Chudново-Berdichev and the plagioclase granites are 2,100 million years old, and the trachytic and pink aplitic-pegmatitic granites of the Zhitomir igneous complex are 1,700-1,750 million years old. — D. B. V.

- 184-78. Li, Pu; Chen, Yu-chi; Tu, Gon-chzhi; Tugarinov, A. I.; Zikov, S. I.; Stupnikova, N. I.; Knorre, K. G.; Poleyaya, N. I.; and Brandt, S. B. Ob absolyutnom vozraste gornykh porod Kitayskoy Narodnoy Respubliki [On the absolute age of rocks of the Chinese People's Republic (with English summary)]: Geokhimiya, no. 7, p. 570-585, 1960.

The results of 45 potassium-argon determinations and 14 lead-uranium-thorium determinations of the age of rocks from different parts of China are tabulated. The oldest rocks are pegmatites in Liaoning province, $2,240-2,560 \times 10^6$ yr. Another cycle is indicated at $1,700-1,900 \times 10^6$ yr, in Liaoning, Kwantung, Shan-hsi, and Inner Mongolia. The Bayun'-Obo series is dated at $1,550 \pm 200 \times 10^6$ yr. Sinian glauconites are $800-1,040 \times 10^6$ yr old, and Cambrian glau-

conites $500 \pm 50 \times 10^6$ yr; this suggests the possibility of correlating the Riphean of the Russian platform ($600 - 1,290 \times 10^6$ yr) with the Sinian of the Chinese-Korean platform ($500 - 1,040 \times 10^6$ yr). The upper age limit of the Hutai series, which forms the basement of the Sinian-Korean shield, is $1,800 \pm 100 \times 10^6$ yr. Magmatism is indicated in the Chinese-Vietnamese shield at 800×10^6 yr ago. Hercynian activity accompanied by mineralization and metamorphism is indicated in the Chinese-Korean platform, and Mesozoic activity in the Chinese-Vietnamese platform. Tertiary intrusions are known in Yunnan province and parts of Fukien. — D. B. V.

- 184-79. Imai, Hideki; Saito, Nobufusa; Hayashi, Shoichiro; Sato, Kazuo; and Kawachi, Yosuke. The absolute age of the granitic rocks in the Miyako-Taro district, Iwate Prefecture [in Japanese with English abstract]: *Geol. Soc. Japan Jour.*, v. 66, no. 777, p. 405-409, 1960.

The absolute age of uraninite from the Yamaguchi mine as determined by the lead method is 100 million years. The deposit is related to the granitic intrusions in the Paleozoic formations of the Miyako-Taro district of north-eastern Japan. The lead age agrees with the geologic relations, which indicate that the time of intrusion of the granites was between Early and Middle Cretaceous. — V. S. N.

- 184-80. Kuno, Hisashi; Baadsgaard, Halfdan; Goldich, Samuel [S.], and Shiobara, Kanji. Potassium-argon dating of the Hida metamorphic complex, Japan: *Japanese Jour. Geology and Geography*, v. 31, no. 2-4, p. 273-278, 1960.

Potassium-argon dating of five biotite samples from the gneisses of the Hida metamorphic complex, central Honshu, Japan, gives an average age of 180 million years, which corresponds to Late Triassic or Early Jurassic. This date may represent the time of the regional metamorphism; however, it is also possible that the complex was formed earlier and that the determined age marks a younger metamorphic event. — V. S. N.

- 184-81. Yesikov, A. D. Predvaritel'nyye rezul'taty i perspektivy deyatel'nosti vozzrastnoy laboratorii IGEM AN SSSR [Preliminary results and prospects of the activity of the age laboratory of the IGEM AN SSSR]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 6th sess., p. 253-256, 1957 (1960).

The methods and processes of absolute age determination of rocks and minerals in the IGEM laboratory of the Academy of Sciences of the U. S. S. R. are analyzed, the accuracy of the results discussed, and measures for further improvement of the laboratory's activities are suggested. — A. J. S.

COSMOGONY

- 184-82. Hibbs, A. R. The distribution of micrometeorites near the earth: *Jour. Geophys. Research*, v. 66, no. 2, p. 371-377, 1961.

Statistical examination of impacts of micrometeorites recorded by the Explorer I satellite in February 1958 leads to the conclusion that the average particle measured was in a closed orbit around the earth rather than on an impact trajectory from a great distance toward the surface of the earth. — D. B. V.

- 184-83. Pettersson, H[ans]. The accretion of cosmic matter to the Earth: *Endeavour*, v. 19, no. 75, p. 142-146, 1960.

Although accretion of cosmic matter to the earth was demonstrated by deep-sea samples taken by the Challenger expedition of 1872-76 and by analyses of Arctic snow made at about the same time, it has only recently been possible to obtain sufficient samples to estimate the temporal and geographic variation of the fall of cosmic matter. The results of recent investigations of long deep-sea cores and air samples collected far from industrial contamination are reviewed. It is calculated that the total annual accretion of cosmic dust is 5 million tons; this is a thousand times greater than the accretion of cosmic spherules. — D. B. V.

- 184-84. Beals, C. S., Innes, M. J. S., and Rottenberg, J. A. The search for fossil meteorite craters: *Current Sci. [India]*, (pt. 1), v. 29, no. 6, p. 205-218; and (pt. 2), v. 29, no. 7, p. 249-262, 1960.

The search for fossil meteorite craters to date has established the probable existence of three such craters of large size and sufficiently great age to justify the belief that others might be discovered by an exhaustive search. A considerable number of circular features in Canada may prove to be the result of meteorite impact, and recent evidence suggests an impact origin for certain cryptovolcanic structures. — D. B. V.

- 184-85. Fish, Robert A., Goles, Gordon G., and Anders, Edward. The record in the meteorites, 3. On the development of meteorites in asteroidal bodies: *Astrophys. Jour.*, v. 132, no. 1, p. 243-258, 1960.

It is proposed that meteorites originated in planetesimals of asteroidal dimensions, heated by some transient internal energy source such as extinct radioactivity. Segregation of metal and silicate phases and mineral differentiation would take place on reasonable time scales even in small bodies. The occurrence of diamonds in meteorites is found to be inconsistent with an origin in large bodies; it is suggested that diamonds were formed as a metastable phase by decomposition of cohenite under localized stress, or upon impact with the earth.

At the onset of melting in an internally heated planetesimal, the equilibrium figure would comprise an inner core of metal and an outer core of silicate; a mantle of chondritic composition, compacted by sintering; and an unconsolidated surface layer. The expected properties of material from each of these layers agree well with those of the known classes of meteorites. Further temperature rise would result in quasi-volcanic eruptions due to evolution of gases and vapors from the interior; this would cause recycling of the material and could lead to the development of many detailed features of meteorites. This hypothesis can explain the capillary veins in stone meteorites and the discrepancies between the observed and predicted abundances of some chalcophile elements in chondrites. Extinct radioactivity seems to be the only possible energy source. — D. B. V.

- 184-86. Ringwood, A. E. Cohenite as a pressure indicator in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 155-157, 1960.

Cohenite, $(\text{FeNi})_3\text{C}$, has been recorded in several iron meteorites. It is analogous to cementite, Fe_3C , which occurs in steels and about whose properties and behavior a large amount of data are available. The enormous an-

nealing periods which iron meteorites have received are many orders of magnitude longer than would be required to decompose cementite completely. The retention of cohenite therefore implies that some other factor has contributed to its stability in meteorites.

The most likely explanation is that meteorites have crystallized under pressures sufficiently high to make cohenite thermodynamically stable. It is calculated that meteorites containing cohenite must have cooled to a temperature of 450°C at pressures exceeding 25,000 atm, in other words deep within a parent body of approximately lunar size. — D. B. V.

- 184-87. Clark, S[ydney] P., Jr., and Kullerud, G[unnar]. Iron meteorites: Carnegie Inst. Washington Year Book 58, July 1, 1958-June 30, 1959, p. 167-170, 1959; reprinted in Carnegie Inst. Washington Geophys. Lab. Ann. Rept. of Director for 1958-1959, 1959.

Information on the pressures and temperatures under which meteorites were formed will make it possible to improve earth models based on meteorites. Although iron and nickel in two metal phases (kamacite and taenite) make up more than 98 percent of the iron meteorites, it is unlikely that a sensitive thermometer and barometer, based only on the compositions of coexisting kamacite and taenite, can be developed. It is possible that the Fe-Ni ratios in the sulfide troilite, the phosphide schreibersite, or the carbide cohenite may provide the information needed to fix both the temperature and the pressure at which the mineralogy of a given meteorite formed. For this purpose that part of the system Fe-Ni-S between the FeS-NiS join and the binary system Fe-Ni have been investigated with two aims in mind: 1) for information on the direction of the tie lines connecting coexisting alloys and nickeliferous troilite, and 2) for knowledge of the melting relations in this system. — V.S.N.

- 184-88. Reed, George W. Activation analysis applied to geochemical problems, *in* Researches in geochemistry: New York, John Wiley and Sons, p. 458-475, 1959.

Activation analysis involves the production of a radioactive isotope by neutron absorption and the subsequent measurement of its amount by counting techniques. The radioactivation technique because of its great sensitivity and freedom from contamination, can be very useful in measuring trace-elements. The discussion in this paper is restricted to the neutron activation study of meteorites. The basic method is discussed and various previous investigations of uranium in meteorites reviewed. The cosmic abundance of uranium is estimated as 7.8×10^{-3} atoms of uranium to 10^6 atoms of silicon. The U, Pb, and He contents and age measurements; the uranium distribution ratio between the silicate and metal phase of planetary bodies; and the excess heat generated in the earth, moon, and Mars by radioactivity are also discussed. Investigations currently in progress are mentioned briefly. — V. S. N.

- 184-89. DuFresne, Ann. Selenium and tellurium in meteorites: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 141-148, 1960.

The selenium and tellurium contents were determined for samples of chondritic meteorites of various ages and conditions. Their concentrations do not follow each other nor the sulfur analyses in any systematic way except that the highest amounts of all three elements occur in Indarch, a carbonaceous chondrite. Some fractionation process evidently has operated. In view of such marked effects, it is not possible to regard the chondritic meteorites as reliable samples of the primitive abundances of these elements nor of other elements. — D. B. V.

- 184-90. Zähringer, J., and Gentner, W. Uredelgase in einigen Steinmeteoriten [Primordial inert gases in some stone meteorites]: Zeitschr. Naturforschung, v. 15a, no. 7, p. 600-602, 1960.

The chondrites Kapoeta and Abee have been found to contain excess amounts of inert gases. From their amounts and isotopic compositions it is concluded that these gases are of primordial origin. Kapoeta contains an excess of all the inert gases, whereas in Abee the primordial component consists mainly of the heavier inert gases. The $\text{Ne}^{20}/\text{Ne}^{22}$ and $\text{Ar}^{36}/\text{Ar}^{38}$ ratios show large deviations from those of atmospheric neon and argon, but krypton and xenon ratios do not. The inert gas content of Kapoeta is similar to that found by Gerling and Levskiy (see Geophys. Abs. 184-91) in the Pesyanoye meteorite, which at the time was regarded as exceptional. — D. B. V.

- 184-91. Gerling, E. K., and Levskiy, L. K. O proiskhozhdenii inertnykh gazov v kamennykh meteoritakh [On the occurrence of inert gases in stone meteorites]: Akad. Nauk SSSR Doklady, v. 110, no. 5, p. 750-753, 1956.

The contents and isotopic compositions of argon, helium, and neon in a number of stone meteorites were measured. Tabulated results also include the argon ages and various isotopic ratios. The isotopic composition of both neon and argon is entirely different from that of atmospheric neon and argon; this agrees with earlier findings. The unusual amounts and compositions of the rare gases in one meteorite, "Staroye Pes'yanoye," cannot be explained by cosmic ray processes; it is suggested that they are of primordial origin, representing gases trapped in the meteorite at the time of its formation. The results of this study support the view that meteorites were formed by the disintegration of one or more bodies of planetary dimensions (see also Geophys. Abs. 165-16). — D. B. V.

- 184-92. Levin, B. Yu., Kozlovskaya, S. V., and Starkova, A. G. Sredniy khimicheskiy sostav meteoritov [Average chemical composition of meteorites]: Akad. Nauk SSSR Meteoritika, no. 14, p. 38-53, 1956.

The chemical composition of meteorites is reviewed comprehensively, and the attempt is made to evaluate the true average composition of meteoritic material free of alteration that occurs as the meteorite passes through the atmosphere. The results are presented in tables. — J. W. C.

- 184-93. Starik, I. Ye., and Shats, M. M. Novyye dannyye po opredeleniyu sodержaniya urana v meteoritakh [New data on determination of uranium content in meteorites]: Akad. Nauk SSSR Meteoritika, no. 18, p. 83-87, 1960.

The uranium content of meteorites is compared with that of analogous terrestrial rocks. The uranium content of olivine from dunite (Webster, N. C.) is 1.1×10^{-7} g per g. In the analyzed chondrites, achondrite, and olivine from pallasite it is $1-2 \times 10^{-7}$ g per g, and in the Sikhote-Alin and Chinge iron meteorites it is less than 1×10^{-9} g per g. The age of meteorites calculated from the ratios $\text{Pb}^{206}/\text{U}^{238}$ and $\text{Pb}^{207}/\text{U}^{235}$ is in agreement with the age now accepted. — A. J. S.

- 184-94. Gerling, E. K., and Levskiy, L. K. Produkty kosmicheskoy radiatsii v Sikhote-Alinskoy meteorite [Products of cosmic radiation in Sikhote-Alin meteorite]: Akad. Nauk SSSR Meteoritika, no. 18, p. 100-105, 1960.

The investigation of isotopes of inert gases in chondrites is continued (see Geophys. Abs. 179-269). The content of inert gases in individual samples of the Sikhote-Alin shower was determined, and the distribution of these gases from the surface to the interior was studied. The sample that contains the greatest quantity of inert gas is thought to have been close to the surface of the original meteor. — A. J. S.

- 184-95. Stulov, N. N. Rentgenometricheskoye issledovaniye veshchestvennogo sostava nekotorykh meteoritov [X-ray investigation of the composition of certain meteorites]: Akad. Nauk SSSR Meteoritika, no. 19, p. 63-85, 1960.

An X-ray analysis of the mineral composition of 20 iron and 3 carbonaceous chondrite meteorites is reported. The crystallographic parameters of kamacite and taenite are given for iron meteorites, and the chemical composition of chromite, troilite, schreibersite, and rhabdite is presented in weight percentage. Hydrated silicates were found in the chondrites analyzed. — A. J. S.

- 184-96. Starik, I. Ye., Sobotovich, E. V., and Lovtsyus, G. P. Opredeleniye soderzhaniya svintsa v zheleznykh meteoritakh [Determination of the content of lead in iron meteorites]: Akad. Nauk SSSR Meteoritika, no. 19, p. 100-102, 1960.

A redetermination was made of the lead content of several iron meteorites, and it was found that the older determinations were exaggerated by the introduction of lead of terrestrial origin from the atmosphere during the fusion and in laboratory experiments. It is possible that the true lead content in the metallic phase of meteorites does not exceed 2×10^{-8} g per g. — A. J. S.

- 184-97. Van Dilla, M. A., Arbold, J. R., and Anderson, Ernest C. Spectrometric measurement of natural and cosmic-ray induced radioactivity in meteorites: Geochim. et Cosmochim. Acta, v. 20, no. 2, p. 115-121, 1960.

A nondestructive method of analyzing meteorites for natural and cosmic-ray induced radioactivity using low-level gamma-ray spectrometry of kilogram samples is reported. Results so far obtained are essentially qualitative but appear to be in agreement with previous chemical measurements of potassium and aluminum-26 in chondrites and achondrites. Cobalt-60 was detected in the Sikhote-Alin siderite but not in old falls such as Odessa and Canyon Diablo.

Thermalization of neutrons in a meteorite requires an appreciable mass. In irons most of the neutrons escape before capture, even in a specimen of one ton original mass. Thus the dependence of the production rate of a neutron capture species like cobalt-60 on meteorite mass is entirely different from that of a spallation product. This should provide a sensitive index of original meteorite mass. — D. B. V.

- 184-98. Shedlovsky, J. P. Cosmic-ray produced manganese-53 in iron meteorites: Geochim. et Cosmochim. Acta, v. 21, no. 1/2, p. 156-158, 1960.

The radioactivity of manganese in 3 iron meteorites (Odessa, Grant, and Williamstown) has been measured. The activities found are attributed to Mn^{53} . The measuring technique is described briefly and results are tabulated.

These results show considerably more Mn^{53} activity than predicted by Sheline and Hooper (1957). Either the low-energy secondary flux is 10 times as great as the primary flux; or else the half life of Mn^{53} is in the 5×10^7 -yr range, and 10^8 yr ago the cosmic-ray flux was several times its present value. As the stone meteorites have apparent cosmic-ray ages between 10^7 and 5×10^7 yr, measurement of the Mn^{53} activity in the metallic phase might settle this point. It is of interest to note that these samples of cosmic-ray produced Mn^{53} are now free of Mn^{54} contamination, whereas all man-made samples contain enough Mn^{54} to mask completely the Mn^{53} activity. — D. B. V.

- 184-99. Murthy, V. Rama. Isotopic composition of silver in an iron meteorite: *Phys. Rev. Letters*, v. 5, no. 12, p. 539-541, 1960.

The isotopic composition of silver in the troilite of the Toluca iron meteorite was determined. The average of three runs gives an Ag^{107}/Ag^{109} ratio of 1.097 ± 0.002 , compared to a terrestrial ratio of about 1.074 ± 0.002 . The excess Ag^{107} may have been caused by selective fractionation during long cooling or during the last stages of nucleosynthesis, or it may be due to the decay of extinct Pd^{107} . If the latter is the case, the time interval Δt between nucleosynthesis and formation of iron meteorites can be estimated.

Assuming a silver content of 0.1 ppm, Δt for the "sudden synthesis" model would be about 8.4×10^7 yr, and for the more commonly accepted "continuous synthesis" model $\Delta t = 4.5 \times 10^7$ yr. The latter value is comparable to the 4×10^7 yr obtained by Anders and Stevens for the Canyon Diablo iron, using the $Pb^{205}-Tl^{205}$ decay scheme (see *Geophys. Abs.* 183-63). — D. B. V.

- 184-100. Baranov, V[ladimir] I. Zadachi vozrastnykh opredeleniy meteoritov [Problems of age determinations of meteorites]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 6th sess., p. 226-253, 1957 (1960).

The lead and inert-gases methods of age determination on meteorites indicate the time of disruption of the parent planet, the remnants of which constitute the meteorites. These methods can also be applied to determination of the age of the crust of the earth. The solution of the problem is presented by a graph of Pb^{206}/Pb^{204} , which is a straight line with an inclination that is a function of time t . For terrestrial rocks the age $t = 4.5 \times 10^9$ yr; for meteorites $t = 0.650 - 4.82 \times 10^9$ yr (see *Geophys. Abs.* 166-23, 180-248). — A. J. S.

- 184-101. Starik, I. Ye., Sobotovich, E. V., and Shats, M. M. Opredeleniye vozrasta meteoritov svintsovo-izotopnym metodom [Determination of age of meteorites by the lead isotope method]: *Akad. Nauk SSSR Meteoritika*, no. 18, p. 88-91, 1960.

The uranium and lead contents and the isotopic composition of lead in 6 stone and 2 iron meteorites were determined by mass spectrometry. The uranium and lead contents in these meteorites are approximately the same. The Pb^{207}/Pb^{206} ages range from 4.3 to 4.5 billion years; the Pb^{207}/U^{235} ages from 4.1 to 7.0 billion years; and the Pb^{206}/U^{238} ages from 3.2 to >20 billion years. — A. J. S.

- 184-102. Macleod, W. N., and Walls, R. Notes on meteorites from Nigeria: Nigeria Geol. Survey Recs. for 1958, p. 21-26, 1960.

Six meteorite falls have been recorded in various parts of Nigeria. The Uwet meteorite, from Uwet in Calabar Province is classified as a normal hexahedrite of the Braunau type with an approximate chemical composition of Fe_{14}Ni . The Udei meteorite, from north of the Benue River near Makurdi, is classified as a mesosiderite. It is the only representative of this type in Nigeria and is comparatively rare elsewhere in the world. The two Git Git meteorites, from near Bogoro in the Lere District of Bauchi Province, and the Karewar meteorite, from Karewar in Katsina Emirate, are white chondrites. The Geidam meteorite, from Garau in the Zajibiri Village Unit of Geidam District, Bornu Province, is a typical chondrite with a moderately high proportion of iron-nickel alloy. The ratio of silicates to iron-nickel is of the order of 4 to 1. Only small pieces were recovered from a meteorite that was observed to break up at a great height over Adamawa Province and the Cameroons in November 1952. — V. S. N.

- 184-103. Pokshivnitskiy, Ye. [Pokrzywnicki, Jersy]. Meteorite Zaboritsa [Zaboritsa meteorite]: Akad. Nauk SSSR Meteoritika, no. 18, p. 106-110, 1960.

The meteorite which fell on March 30, 1819, at Zaboritsa ($\phi=50^{\circ}17'$; $\lambda=27^{\circ}41'$) in Poland is studied from the original report to Wilna University. The weight was reported to be about 19.75 kg; it possessed magnetic properties, belonged to the class of crystalline chondrites, had a specific gravity of 3.49, and had a spectrophotometric color index of +1.03^m. — A. J. S.

- 184-104. Kostov, I. Meteority Sofiyskogo universiteta [The meteorites of Sophia University]: Akad. Nauk SSSR Meteoritika, no. 19, p. 155, 1960.

The name (or locality), weight, and date of the fall of 3 meteorites from Bulgaria, and 19 meteorites from other countries, collected by the faculty of mineralogy, petrography, and economic minerals of Sophia University are listed. — A. J. S.

- 184-105. Kashkay, M. A., Sultanov, G. F., Eminzade, T. A., and Aliyev, V. I. Yardymlinskiy zheleznyy meteorit [Yardymly iron meteorite]: Priroda, no. 9, p. 109-110, 1960.

Witnessed accounts are given of the fall of an iron meteorite at Yardymly, Azerbaijan S.S.R., on November 24, 1959. Fragments of the meteorite weighing 360 kg, 127 kg, 11.3 kg, 5.93 kg, and 5.7 kg were recovered. — A. J. S.

- 184-106. Florenskiy, K. P., Vronskiy, B. I., Yemel'yanov, Yu. M., Zotkin, I. T., and Kirova, O. A. Predvaritel'nyye rezul'taty rabot tungusskoy meteoritnoy ekspeditsii 1958 g. [Preliminary results of the work of the Tungus meteoritic expedition of 1958]: Akad. Nauk SSSR, Meteoritika, no. 19, p. 103-134, 1960.

The results of field work in 1958 in the region of fall of the Tungus meteorite in central Siberia are reported. The area of the forest felled by the meteorite was surveyed, and samples of soil in the area were collected and ex-

amined for metallic remnants of the meteorite. The total area of the felled forest is about 1,500 km². The samples of soil tumbled for meteoritic particles were treated magnetically for separation of magnetic particles. In several samples a number of extremely small spherules, probably of magnetite or silicate, were found; these are considered to be of cosmic origin but not necessarily remnants of the Tungus meteorite. Iron particles (larger than 0.1 mm) found contain no nickel and are considered to be terrestrial. — A. J. S.

- 184-107. Vronskiy, B. I. O nakhodke zheleznogo meteorita susuman [On the finding of the iron meteorite Susuman]: Akad. Nauk SSSR Meteoritika, no. 19, p. 135-142, 1960.

The iron meteorite Susuman was found in November 1957 at lat 62°43'17" N. and long 148°07'49" E. by a mine worker in the Magadan region, northeastern Siberia. The meteorite was broken by the miners into 3 parts: 12.1 kg, 6.7 kg, and about 0.1 kg. The specific gravity is 7.8. The meteorite was found at a depth of 32 m in alluvial permafrost; the time of fall is considered to be 15,000-20,000 yr ago. — A. J. S.

- 184-108. Murayama, S. Japanese meteorites and the collection of the National Science Museum [in Japanese]: Nat. Sci. and Museums, v. 27, no. 3/4, p. 1-19, 1960.

Thirty meteorites that have fallen on the Japanese Islands from 1688-1958 are described. The meteorites are listed in a table which gives the name, class, date of fall, locality, longitude, latitude, number of individuals, and the total known weight of each. The location of each meteorite is shown on a sketch map. — V. S. N.

- 184-109. Edwards, A. B. The Lismore meteoritic iron: Royal Soc. Victoria Proc., new ser., v. 72, pt. 2, p. 93-94, 1960.

A mineralogic description is given of the Lismore meteorite collected about 1½ miles west of the township of Lismore, Victoria, Australia. A few grams from the freshly cut surface of the main mass gave the following analysis: Fe, 91.40 percent; Ni, 7.79 percent; Co, 0.56 percent; and traces of P and S. Some schreibersite is present and a troilite nodule was exposed in a polished slice. — V. S. N.

- 184-110. O'Keefe, John A. Tektites as natural earth satellites: Science, v. 133, no. 3452, p. 562-566, 1961.

A study of the distribution of meteorites from the great meteor procession of February 9, 1913 (the "Cyrillids") leads to the conclusion that the theory of a lunar origin for tektites can be reconciled with the criticisms of Barnes, Kopal, and Urey (see Geophys. Abs. 175-395, -396, -397) with respect to their distribution, if it is assumed that the orbits are measurably eccentric, that the glassy form of tektites is the result of atmospheric ablation, and that lunar material also reaches the earth in considerable quantity in some other, probably inconspicuous, form. The conclusion of Kopal that some source nearer than the moon is required to account for the narrow distribution of the tektites is valid in the sense that the breakup into separate bodies takes place in the earth's atmosphere. — D. B. V.

- 184-111. Cohen, Alvin J. Trace element relationships and terrestrial origin of tektites: *Nature*, v. 188, no. 4751, p. 653-654, 1960.

Partial volatilization of several of the component oxides during formation of tektite glass might account for the negative correlation of Al_2O_3 , FeO , MgO , and CaO with silica, without invoking a mixing of materials as suggested by Cherry, and others (see *Geophys. Abs.* 183-78). In order to test the proposition that tektites are produced at high temperatures and that volatilization takes place, the gallium-germanium ratios of a series of tektites and related terrestrial materials have been determined. It is clear from the results, which are tabulated, that tektites have higher Ga/Ge ratios than terrestrial impactite glasses. That volatilization took place is well shown in an australite sample, where the second melting that produced the flange has caused an increase in gallium and a decrease in germanium compared to the sandstone at the crater. The high temperature of formation of tektite glasses, the quenching of the melt before thorough mixing can take place, and the shapes (before secondary melting) all indicate an impact origin. — D. B. V.

- 184-112. Barnes, Virgil E. Significance of inhomogeneity in tektites: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 13, p. 328-338, 1960.

On the basis of petrographic examination of 37 tektites from different parts of the world, it is concluded that the lechatelierite present in some tektites originated from quartz similar to that in various terrestrial rocks; that tektites were melted at a temperature in excess of $1,710^\circ\text{C}$ and remained molten only a short time; that australites, indochinites, and Java tektites may all represent one shower; and that two tektite showers are present in Texas, the younger of which may correlate with the Georgia tektites. If tektites were formed from terrestrial material, the explosive force that created some showers must have been sufficient to throw molten rock out of the atmosphere to solidify before plunging back to be partly remelted. — D. B. V.

- 184-113. Taylor, S. R. Abundance and distribution of alkalic elements in australites: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 85-100, 1960.

The mean contents of the alkali elements in 14 australites from different parts of Australia have been determined. The values are of the same order of magnitude as those for terrestrial abundances and match abundances in sedimentary rocks better than those in igneous rocks. The sodium and potassium averages are virtually identical with those found by Pinson and Schnetzler (1959) for philippinites and indochinites. The dispersion in concentration of the alkali elements is much smaller than in specific terrestrial rock types such as granites but distinctly greater than that found in chondrites. All the elements show close association with one another. It is concluded that such a coherence arises from a physical process such as mixing rather than from a chemical process. Any process invoked to explain the chemical composition of australites must not fractionate the alkali elements. A regional variation in composition, with higher alkali element concentrations toward the west, is observed. — D. B. V.

- 184-114. Reynolds, J[ohn] H. Rare gases in tektites: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 101-114, 1960.

Eight tektites from a number of localities have been examined for their contents of potassium, atmospheric argon, radiogenic argon, atmospheric neon, and possible cosmogenic neon. The helium diffusion rate of tektites was found to be so high that no radiogenic or cosmogenic helium can be retained.

The recent tektites should retain a substantial amount of any cosmogenic neon contained at the time of fall. In no case was any excess Ne^{21} detected. From the upper limits of original Ne^{21} content, a maximum "flight time" since last melting has been computed for each tektite. A result of 28,000 yr for a tektite from Kalgoorlie, Australia, is in apparent disagreement with the finding by Ehmann and Kohman of radioactive Al^{26} in australites (see *Geophys. Abs.* 175-330).

Potassium-argon ages have been computed for each tektite; these range from 0 to 32 million years and are usually in agreement with the stratigraphic age. Data in this paper do not support a recent suggestion that the tektites of Czechoslovakia and Georgia are part of the same fall (see *Geophys. Abs.* 179-43). — D. B. V.

- 184-115. Koenigswald, G. H. R. von. Tektite studies: Koninkl. Nederlandse Akad. Wetensch. Proc., ser. B, v. 63, no. 2, p. 135-141 (pt. 1) and p. 142-153 (pt. 2), 1960.

The first part of this paper discusses the age of the Indo-Australian tektites and the second part their distribution. It is concluded that the Indo-Australian tektites form a single natural group of the same chemical composition, which came down early in Middle Pleistocene time and arrived simultaneously in different "clouds" belonging to the same "swarm." There are primary differences between clouds, indicated by average size and surface sculptures. The peculiar form of the australites is believed to be due to longer passage through the atmosphere rather than to primary stratification within the cloud as a whole. — D. B. V.

- 184-116. Vorob'yev, G. G. Problema tektitov i silika-glassov [The problem of tektites and silica-glasses]: Akad. Nauk SSSR Meteoritika, no. 19, p. 26-62, 1960.

This is a comprehensive review of silica-glasses, impactites, fulgurites, and tektites. Ten varieties of tektites (the moldavites, australites, tasmanites, billitonites, indochinites, philippinites, livites, americanites, bedia-sites, and schonites) are classified according to their geographic and geologic locations, general appearance, shape, structure, physical properties, chemical composition, isotopic composition, absolute age, and gaseous and solid inclusions. An historical survey of the theories of origin of tektites is also given. The bibliography lists 155 titles. — A. J. S.

- 184-117. Firsoff, V. A. Strange world of the moon: New York, Basic Books, Inc., 226 p., 1959.

The present condition of the moon with special reference to the atmosphere, surface, and subsurface structure is the main subject of this book, which is designed for the nonspecialized reader. An appendix has been provided for treatment of mathematical arguments. The 16 chapters' headings are as follows: dead or alive; the importance of being a satellite; the earth's fair child or a founding?; the telescopic panorama; the mountains of the moon; meteorite or lunavoes?; the sunless sea; realities or shadows?; seasonal changes; colors and hues; between the heat and the cold; the vexed question of lunar atmosphere; structure of the lunar air; wherein the answer lies; water and snow; and life? — V. S. N.

- 184-118. Bülow, Kurd von. Gesichtspunkte zur Beurteilung der ersten Photos von der Rückseite des Mondes [Aspects of the evaluation of the first photographs of the rear side of the moon (with English summary)]: Gerlands Beitr. Geophysik, v. 69, no. 3, p. 129-139, 1960.

In spite of ambiguities in the first photographs of the rear side of the moon due to indistinctness, vertical illumination, and relatively small scale, certain facts can be ascertained. There are no unknown features. True maria certainly are present and epicontinental maria probably exist. Craters seem to be very numerous, and there are indications of north-south structural trends. The belt of maria on the front side continues to the back. The differences between the front and back of the moon are in degree rather than in kind. — D. B. V.

- 184-119. Brockhaus, K., and Joks, H. C. Bestimmung der hypsometrischen Kurve des Mondes aus Beobachtungen von J. Franz [Determination of the hypsometric curve of the moon from observations by J. Franz (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 1, p. 9-23, 1960.

Absolute heights were determined from the differences of the coordinates for 547 objects measured by Franz on moon photographs taken at different libations. In spite of errors due to incompleteness of the published data, 150 heights thus determined corresponded exactly with heights determined by Schrutka-Rechtenstamm; however, a comparison of 41 heights with those determined independently by Weimer showed no correlation.

A hypsometric curve is unimodal and asymmetric, and shows no similarity to the curve previously determined by Joks (1957) from Ritter's hypsographic map. — D. B. V.

- 184-120. Berlage, H. P. Sur l'origine des satellites en général et de la Lune en particulier [On the origin of satellites in general and of the moon in particular]: Ciel et Terre, v. 75, no. 5/6, p. 173-186, 1959.

Satellite systems are small-scale replicas of the planetary system; every theory of evolution of the planets is applicable to that of the satellites, and any theory that does not explain both is invalid. It is shown that a toroidal disk would spontaneously become a series of concentric rings, and these rings surrounding a planet in turn would become pairs of satellites. Mars, with its one pair of satellites with circular orbits coinciding with the planet's equator, corresponds exactly to the theoretical ideal. The moon was created at a distance of about 10 earth radii from the center of the earth; a second satellite only 1/10 as heavy might have revolved at a distance of 30 earth radii to be destroyed by the moon as it moved to a distance of 60 earth radii. It is also possible that the second satellite was larger than the moon and was formed from a ring closer to the earth, so that it was quickly drawn back to the earth. — D. B. V.

- 184-121. Kellogg, W. W. (chairman). Earth sciences session: Lunar and Planetary Explor. Colloquium (Sept., 1959) Proc., v. 11, no. 1, p. 15-33, 1959 [1960].

The earth sciences session of this colloquium was opened with a keynote speech by J. Green in which the problem of the origin of the craters of the

moon was introduced. The need for terrestrial research based both on the hypothesis of internal (defluidization) origin and the hypothesis of external (impact) origin is emphasized. J. Green presented the case for internal origin of the craters and E. M. Shoemaker the case for the external or impact origin; the latter analyzed the form of known maar and meteor craters in the United States and Mexico. — V. S. N.

- 184-122. Brereton, Roy G. Lunar exploration: *Geotimes*, v. 5, no. 3, p. 8-9, 27, 1960.

The first step in exploration of the moon will be a series of unmanned vehicles designed to impact on the moon, orbit the earth-moon system, orbit the moon, and finally soft-land an instrument package.

The second step will involve more powerful and more sophisticated manned rockets. The first men on the moon should be a geologist, a physicist, and an engineer. Preliminary geophysical work at the landing site should consist of a seismic survey to determine the elastic properties of surface and sub-surface rocks, depth of surface material, and general seismicity of the moon; a gravity survey to determine anomalous density contrasts and to obtain information on lunar mass; a magnetic survey; and electrical surveys to locate any fissures and cracks hidden under surface dust. — D. B. V.

- 184-123. Oilweek. Tool to drill on moon? *Oilweek*, v. 11, no. 42, p. 36, 1960.

The completion of a lunar drilling system to be rocketed into space by an unmanned space ship sometime in 1963 is announced. The tool is 5 feet high, will weigh 10 pounds on the moon, and will drill a small diameter hole to a depth of several feet in either dust or a granite-like rock. — V. S. N.

EARTH CURRENTS

- 184-124. Yungul, S. H. Time variations of the ellipticity and preferred direction of the Pc telluric field: *Jour. Geophys. Research*, v. 66, no. 2, p. 557-561, 1961.

The objective was to determine the preferred direction of the telluric currents, at one point on the earth, that would depend only on the geologic setting. This is called the direction of the "geologic ellipse." From six days recording an experimental relation between the variations of the azimuth of the long axis and the ellipticity of the statistical "telluric ellipse" was established. By means of such a relation, it is possible under favorable conditions to obtain the direction of the geologic ellipse from only a few hours records, although the azimuth of the 10-min statistical telluric ellipse may vary 100° in 3 hr, and that of the daily statistical telluric ellipse may vary a few tens of degrees from day to day. — Author's abstract

- 184-125. Verő, Josef. Die Bestimmung der tellurischen Stationsellipsen [The determination of telluric station ellipses (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 5, p. 257-268, 1960.

The "tangent method" of interpreting telluric measurements is described. This method gives a tensor, the so-called "station ellipse," which characterizes the resistivity conditions of the underground and facilitates telluric measurements. Formulas for determining station ellipses from the measurements are given in an appendix. — D. B. V.

- 184-126. Smith, H. W., Provazek, L. D., and Bostick, F. X., Jr. Directional properties and phase relations of the magnetotelluric fields at Austin, Texas: Jour. Geophys. Research, v. 66, no. 3, p. 879-888, 1961.

Directional properties and phase relations of the variable electric and magnetic field components of selected data samples taken at Austin, Tex., are presented in the form of X-Y plots. Power density spectra of component signals are shown, and data recording and analysis techniques are described and illustrated for the selected data samples.

The representativeness and absolute accuracy cannot be ascertained until a more extensive observation and analysis program is completed. Measurements obtained on three additional days appear to have the same general character as the sample period, suggesting that this sample does not represent an isolated case. In particular, the application of narrow-band filtering of the signals at a number of different frequencies holds the greatest promise of yielding significant new data in the area. — D. B. V.

- 184-127. Troitskaya, V. A. Pulsation of the earth's electromagnetic field with periods of 1 to 15 seconds and their connection with phenomena in the high atmosphere: Jour. Geophys. Research, v. 66, no. 1, p. 5-18, 1961.

Preliminary results of investigations of earth current pulsations in the period range of 1 to 15 sec are presented. Data of 5 earth current stations in the Arctic, 2 in the Antarctic, and 10 in middle latitudes of the U. S. S. R. were used as well as data of high-sensitivity magnetic field (Z) recording instruments at 3 stations. Several characteristic types of pulsations were defined and correlated with high-atmosphere phenomena. Short irregular pulsations ($T \sim 1-15$ sec) that constitute the microstructure of several forms of macroscopic disturbances of the magnetic field are closely correlated with aurora, and "pearl" type pulsations ($T \sim 1-4$ sec) of regular form are correlated with cosmic-ray bursts in the stratosphere. — D. B. V.

- 184-128. Berdichevskiy, M. N., and Raspopov, O. M. Statisticheskiy metod obrabotki nablyudeniy v metode telluricheskikh tokov [Statistical method of treatment of observations in the method of telluric currents]: Prikladnaya Geofizika, no. 27, p. 64-72, 1960.

The method of statistical treatment of telluric current data, proposed originally by Kunetz and Kántás (see Geophys. Abs. 170-90, 171-124), is developed and supported by analysis and field investigations. Under conditions of nonlinear polarization of the telluric current field, quasi-sinusoidal form of telluric impulses, and parallel arrangement of the base and field measuring lines, the radiosynchronization procedure in telluric measurements can be eliminated, and a better stability of telluric measurements achieved. — A. J. S.

- 184-129. Cantwell, T., and Madden, T. R. Preliminary report on crustal magnetotelluric measurements: Jour. Geophys. Research, v. 65, no. 12, p. 4202-4205, 1960.

Some preliminary work on the determination of the earth's electric conductivity structure through simultaneous measurements of the natural electric and magnetic fields is reported. The work was confined to frequencies of 0.005 to 1 cycle per second, with skin depths distributed through the crust. The field measurements were made mainly in Massachusetts, with the majority of data obtained at Littleton.

Assuming a resistivity of 8,000 ohm-m in the surface layer, a two-layer interpretation fits the data reasonably well, with the upper layer about 70 km thick and resistivity in the lower layer less than 80 ohm-m; but it is not suggested that the earth's conductivity structure is actually as simple as this. Sources of error are discussed. — D. B. V.

- 184-130. Wescott, E[ugene] M. Magnetic and telluric current disturbances in Alaska: *Geophysics*, v. 25, no. 6, p. 1242-1250, 1960.

Much of Alaska lies in or near the auroral zone, where magnetic and telluric current disturbances are large compared to those at lower geomagnetic latitudes. Pronounced and different diurnal variations of disturbance are evident from analysis of K indices from Barrow, College, and Sitka magnetic observatories. The quietest period for magnetic or electrical surveying is the late morning and afternoon hours locally. Recordings of telluric current disturbances can be used as a sensitive indicator of ionospheric activity. The large amplitude and rich frequency spectrum of the telluric currents suggest their use as a prospecting tool in Alaska. — Author's abstract

- 184-131. Hessler, V. P. Telluric current micropulsations on Arctic Drifting Station Charlie: *Nature*, v. 188, no. 4750, p. 567-568, 1960.

Micropulsations of less than 1-sec period were recorded for an interval of more than 2 hr on December 11, 1959 by telluric current recording equipment that operated on Arctic Drifting Station Charlie during October 15-December 31, 1959. The frequency of these micropulsations was about 70 cycles per minute, and the rate of fluctuation tended to be very uniform throughout the activity; amplitude ranged from 0.05 to 0.10 mv per km. The circumstances of the experiment assure beyond any reasonable doubt that these were natural micropulsations and not variations introduced by the instrumentation. No previous record of telluric current micropulsations of this short period is known. — D. B. V.

- 184-132. Subieta, Marian. Uwagi o dolnośląskich łupkach grafitowych [Remarks on Lower Silesian graphitic schists (with English summary)]: *Przegląd Geol.*, v. 8, no. 10, p. 532-533, 1960.

Exploration for graphite was renewed in Lower Silesia in 1959 using the earth current method. Quartz-graphite schist occurs in narrow, steeply dipping lenses interlayered with other schists. The graphite zones exhibit minimum potentials. — J. W. C.

- 184-133. Rikitake, Tsuneji. Electromagnetic induction in a hemispherical ocean by Sq: *Jour. Geomagnetism and Geoelectricity* [Kyoto], v. 11, no. 3, p. 65-79, 1960.

A theory of electromagnetic induction within a hemispherical conducting sheet is described and applied to induction by geomagnetic Sq variations in a large ocean of uniform depth bounded by two meridians. The patterns of the induced currents are illustrated for the 24- and 12-hourly components. The effect of self-induction, which is rather important, is taken into account. The magnetic fields produced by the currents induced in the ocean amount to several gammas, and the electric field in the sea associated with the induction would be of the order of a few millivolts per kilometer. — D. B. V.

Bhattacharyya, B[ismal] K[ishna]. Correlation studies of radio-aurora, magnetic, and earth-current disturbances. See *Geophys. Abs.* 184-47.

- 184-134. Duke, C. Martin. The Chilean earthquakes of May 1960: *Science*, v. 132, no. 3442, p. 1797-1802, 1960.

The Chilean earthquakes of May 1960 were perhaps the largest to afflict a heavily populated area since those of San Francisco in 1906 and Tokyo in 1923. Besides the major shocks there were several others of destructive effect, and a tsunami was created which was responsible for most of the deaths in Chile and caused loss of life and property as far away as Hawaii and Japan.

The first large shock, magnitude 7.5 on the Richter scale, occurred on May 21 at 10:03 G. c. t.; its epicenter was near Concepción. The principal shock occurred on May 22 at 19:11 G. c. t., and the epicenter was near the coast at about the latitude of Puerto Montt. A focal depth of 50 km has been inferred from macroseismic evidence. Aftershocks included several of magnitude 7.5 to 8, and one of magnitude 7 occurred as recently as August 14. Construction of an isoseismal map will be difficult due to overlapping effects of the shocks.

Subsidence of 1.6 m occurred in the Valdivia region. Lava erupted from a new vent in the side of Mount Puyehue. Damage to structures is discussed. Buildings erected since 1939, when a new building code was put into effect following a disastrous earthquake in the Concepción region, suffered less damage than older buildings. Errors in design or construction or lack of knowledge about the behavior of the foundations in earthquakes were responsible for most of the damage to the newer buildings. — D. B. V.

- 184-135. Jordan, James N. The Chilean earthquakes of 1960: *Geotimes*, v. 5, no. 5, p. 8-11, 1961.

As a result of the swarms of earthquakes that began in Chile on May 21, 1960, and have continued to the present, about 2,000 persons were killed, a half million were made homeless, and property damage in Chile totals about 500 million dollars. Widespread damage due to tsunami occurred on many Pacific Islands and around the perimeter of the Pacific Ocean. The latitude range (lat $37\frac{1}{2}^{\circ}$ - 51° S.) and the tremendous energy release within a relatively short interval (5 shocks of magnitude 7 or greater within 2 days) are unique. Preliminary epicentral locations have been made for 70 of the several hundred shocks; the majority of these had magnitudes greater than 6. Depths of the larger and more destructive shocks vary between 40-60 km; the epicentral area of these seems to fall in the ill-defined border zone of the two major Cretaceous geosynclines—the Andean and the Magellan. The Coast Ranges-Central Valley Fault Zone is believed to be the major structure involved in the shocks although earth and rock slides in the Andes followed closely a line of volcanoes (only one of which was reactivated) more or less parallel to this structure. — V. S. N.

- 184-136. Fiedler, Günther. Seismological study of the Caracas earthquake of 15 April, 1960 and problems of earthquake prediction: *Bol. Inf.*, v. 3, no. 5, p. 133-137, 1960.

The instrumental results at the Cagigal Observatory from the small earthquake that occurred near Caracas, Venezuela, on April 15, 1960, place the epicenter of the shock in the sea about 20 km north of Macuto with a focal depth of about 10 km below the sea floor. A study of the epicenters of recorded earthquakes around the Caracas area suggests the presence of two fault systems: an ENE-WSW trending system between Maracay and Higuerote, and a NE trending system which crosses the other one near Cúa, and includes the focuses of the most disastrous earthquakes in the Caracas region. A system of earthquake prediction based on observation of compressional and dilatational tensions in the interior of the earth that are expressed at the surface as inclinations is recommended. — V. S. N.

- 184-137. Fiedler, Günther. Caracas earthquake of June 1960: Bol. Inf., v. 3, no. 7, p. 208, 1960.

On June 18, 1960, an earthquake occurred with a focus 35 km NW to NNW of the Seismological Institute, Caracas, Venezuela. The intensity had a mean value of 5.5 on the Mercalli-Caucani-Sieberg scale, and horizontal ground acceleration reached a maximum value of 8 cm per sec⁻² indicating no material damage could have occurred. — V. S. N.

- 184-138. Belotelov, V. L., Savarenskiy, Ye. F., and Feofilaktov, V. D. O-predeleniye energii zemletryaseniya 15 noyabrya 1959 g. [Energy determination of the earthquake of November 15, 1959]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1593-1597, 1960.

The energy of body and surface seismic waves from the earthquake in Greece (38° N. and 20.3° E.) that occurred on November 15, 1959 at 17h08m40s was calculated. The energy of the incident body waves ranged from 170 to 600 ergs per cm² for P-waves and from 190 to 670 ergs per cm² for S-waves; the total surface wave energy was 15,800 ergs per cm². The magnitude was 6.8, and intensity 8-9 points. The energy at the focus E_p+E_s was 3.2X10²⁰ 11.4X10²⁰ ergs. — A. J. S.

- 184-139. Butovskaya, Ye. M., Vvedenskaya, N. A., Iodko, V. K., Kondorskaya, N. V., Semenov, P. G., Treskov, A. A., Ulomov, V. I., and Tskhakaya, A. D. Byulleten' sil'nykh zemletryaseniyy SSSR za 1957 g. [Bulletin of strong earthquakes in the U.S.S.R. for the year of 1957]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 3-26, 1960.

The paper gives: (1) the catalog of earthquakes of M₂ that occurred in the U.S.S.R. in 1957; (2) the map of the epicenters of the earthquakes; and (3) a brief description of the strongest earthquakes. — Authors' abstract, A. J. S.

- 184-140. Puchkov, S. V., and Khovanova, R. I. Ekspeditsionnyye seysmicheskiye nablyudeniya v yugo-zapadnom Pribaykal'ye v 1958-1959 gg. [Seismic observations of the expedition in the southwest Baikal region in 1958-59]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 30-39, 1960.

An expedition was sent to study in detail the seismic regime of the southwest part of the Baikal region in the area adjacent to the zone of the Mondy earthquake of 1950, and to improve and develop methods of instrumental seismic regionalization. Four seismic stations were established, and observations were made from August 1958 to May 1959.

A map shows the distribution of epicenters of earthquakes recorded in that period, distinguished according to energy. Three strong earthquakes occurred, two at Kyren on August 10 and October 22, and the third about 50 km north of Arshan on October 29. The coordinates of the August 10 and October 22 shocks were calculated, but the epicenter of the October 29 shock has not yet been determined.

Results of studies of periods, amplitude ratios, and attenuation of P- and S-waves in local earthquakes, made in connection with seismic regionalization problems, are also reported briefly. — D. B. V.

- 184-141. Khovanova, R. I. Kyrenskoye zemletryaseniye 22 oktyabrya 1958 g. [The Kyren earthquake of October 22, 1958]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 40-43, 1960.

The coordinates of the first Kyren earthquake on August 10, 1958 have been determined instrumentally to be $\phi=51.73^\circ$ N., $\lambda=101.93^\circ$ E., $h=10$ km; its intensity, calculated instrumentally, was 5-6 points. A second strong earthquake in the same area on October 22 at 8^h34^m was well recorded by the temporary seismic stations in the area. The coordinates of this shock were determined from P-wave arrivals at Arshan, Shimki, Mondy, and Zhemchug, using the methods of hyperbolas, as $\phi=51.45^\circ$ N., $\lambda=102.08^\circ$ E. The position obtained by the analytical method, using the P-wave arrivals at these four stations, corresponds well with these values and with a focal depth of 10 km.

Both epicenters are close to a major regional fault along the northern edge of the Tunkin basin, on which movement evidently took place. The dip of the fault, calculated from data of the first earthquake, is 30° , or 45° if data from the second are used. Fault plane solutions by Vvedenskaya's method suggest the movement on the fault was in opposite directions in the two shocks.

Macroseismic data on the October earthquake are summarized briefly at the end of the paper. — D. B. V.

- 184-142. Misharina, L. A. Rezul'taty opredeleniya gipotsentrov Kyrenskikh zemletryaseniya 1958 g. metodom pryamolineynykh epitsentralay [Results of determination of the focus of the Kyren earthquakes of 1958 by the method of rectilinear epicentrals]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 44-45, 1960.

The focal coordinates of the Kyren earthquake of August 19, 1958, were determined by constructing three "rectilinear epicentrals" based on observations at the temporary stations at Kyren, Zhemchug, Arshan, and Mondy, and the permanent stations at Kyakhta and Irkutsk. These lines intersect at $\phi=51.72^\circ$ N., $\lambda=101.96^\circ$ E. Depth of focus is 9 km. P-wave velocity is 6.49 km/s according to data of the permanent stations, and 5.7 km/s according to that of the temporary stations; by the differential method, observations at Irkutsk and Kyakhta give a P-wave velocity of 6.5 km/s. S-wave velocities are 3.65 and 3.66 km/s, according to the traveltimes and the differential method, respectively. Sediment thickness in the basin is calculated to be about 2 km for a velocity of 2.9 km/s in the layer.

These results are confirmed by those obtained for the second Kyren earthquake on October 22, 1958; for this, $\phi=51.75^\circ$ N., $\lambda=102.16^\circ$ E., $h=13-14$ km, sediment thickness=2 km, and velocity in sediments=2.2 km/s. — D. B. V.

- 184-143. Aprodov, V. A. Seysmotektonicheskiye nablyudeniya v rayone Severokhangayskogo zemletryaseniya 1905 g. (MNR) [Seismotectonic observations in the area of the North Hangay earthquake of 1905 (Mongolian People's Republic)]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 91-97, 1960.

Two 11-point-intensity earthquakes have occurred in Mongolia in the last one hundred years: the North Hangay on July 9, 1905 and the Gobi-Altai on December 4, 1957. Even after 53 years, the earthquake faults of the former are well preserved; they can be traced for tens of kilometers and the nature of movement on them can be ascertained. Details of the main fault and the secondary fault branching southward from it near Undur-Hangay are discussed against their background of recent deformation. — D. B. V.

- 184-144. Golenetskiy, S. I., and Pshennikov, K. V. O zemletryaseni 7 fevralya 1957 g. v severnoy Mongolii [On the earthquake of February 7, 1957 in northern Mongolia]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 98-107, 1960.

The earthquake of February 7, 1957 at 4^h35^m local time (February 6 at 20^h35^m G. m. t.) was felt in the upper Angara valley, southwestern Transbaikalia, and northern Mongolia. In places its intensity reached 6-7 points. The epicenter was near the eastern end of the Dzhdin range. Using data from three near stations (Kyakhta, Kabansk, and Irkutsk) and from 15 others in the U. S. S. R., the epicentral coordinates are calculated as $\phi = 50.15^\circ \pm 0.06^\circ$ N., $\lambda = 105.46^\circ \pm 0.04^\circ$ E., $t_0 = 20^h 34^m 56.1^s \pm 0.3^s$. — D. B. V.

- 184-145. Solonenko, V. P., and Florensov, N. A. Gobi-Altayskoye zemletryaseniye 4 dekabrya 1957 g. [The Gobi-Altai earthquake of December 4, 1957]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 85-89, 1960.

This is virtually the same as the paper published in Priroda, no. 2, p. 61-66, 1960 (see Geophys. Abs. 183-113). — D. B. V.

- 184-146. Sapporo, D. M. O. The investigations on the Teshikaga earthquake of Jan. 31, 1959 [in Japanese]: Quart. Jour. Seismology [Tokyo] v. 25, no. 1, p. 9-17, 1960.

On January 31, 1959, the Teshikaga earthquake consisting of two major shocks of magnitude greater than 6 occurred in northeast Hokkaido, Japan. The first shock at 05^h39^m was located at lat 43°22.9' N., long 144°23.7' E. and the second at 07^h17^m was located at lat 43°28.8' N., long 144°23.7' E. Seismograph data including aftershock data are illustrated in maps and tables. — V. S. N.

Schulz, R[udolf], and Weyl, R[ichard]. Earthquakes and crustal structure in northern Central America. See Geophys. Abs. 184-426.

- 184-147. Petrushevskiy, B. A. O svyazi mezhdu zemletryasenyami maksimal'noy sily i geologicheskoy obstanovkoy [On the relation between earthquakes of maximum force and geologic conditions]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 28-35, 1960.

In the western part of the U. S. S. R. a systematic relation between seismic and structural phenomena is shown for three types of structural elements: (1) zones of Alpine folding (Caucasus, Turkmen S. S. R.); (2) young platform regions with folded Paleozoic basement (Urals, Kyzyl-Kum); and (3) platform areas, regardless of age, where preexisting structures have been reactivated in geologically recent times (Tien Shan).

Data on 26 earthquakes of magnitude 7 $\frac{1}{4}$ or more that occurred in Eurasia in 1897-1957 and on 26 earthquakes of magnitude 7 $\frac{3}{4}$ or more that occurred throughout the world in 1904-56 are tabulated. Examination of these data leads to the conclusion that the reactivated platform areas are much more favorable for the occurrence of very strong earthquakes than those in the Tethys zone of Alpine folding. — D. B. V.

- 184-148. Popov, V. V. Rol' inzhenerno-geologicheskikh usloviy v detal'nom seysmicheskoy rayonirovaniy [The role of engineering-geologic conditions in detailed seismic regionalization]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 80-87, 1960.

In planning and building industrial establishments, cities, hydrotechnical, and other constructions in the U. S. S. R. it has been the custom to make detailed maps of seismic regionalization on a scale of 1:10,000 to 1:25,000 and

sometimes even as large as 1:1,000 or 1:1,500. These detailed seismicity maps are compiled on the basis of information obtained by detailed geologic, hydrogeologic, and engineering-geologic mapping and by detailed examination of the effects of earthquakes in a given area in addition to seismological data. Maps of engineering-geological regionalization and seismic regionalization and a geologic section in the vicinity of Gori in the Georgian S. S. R. are reproduced to illustrate the relationship of the nature of the ground to seismic regionalization. — D. B. V.

- 184-149. Kats, A. Z. Seysmicheskoye microrayonirovaniye zony Sochi-khosta [Seismic microregionalization of the Sochi-Khosta zone]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 27-31, 1960.

A brief account is given of a plan for seismic microregionalization based on values of dynamic deformation of the ground. A seismic microregionalization map of the Sochi-Khosta zone is given. — A. J. S.

- 184-150. Rustanovich, D. N. Epitsentral'naya zona Krasnopolyanskikh zemletryaseniy [Epicentral zone of Krasnaya Polyana earthquakes]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 90-98, 1960.

The seismic activity of Krasnaya Polyana and adjacent regions of the northwest slope of the Caucasus and Black Sea coastal region is discussed in the light of 8 earthquakes of 6-7 points intensity, 48 of 5-6 points, and 178 of 3-4 points, which have occurred during the last 126 years. The hypocenters were located at depths of about 10 km, rarely at 18-20 km. The energy level of the earthquakes studied indicates that the region has a relatively low seismicity. — A. J. S.

- 184-151. Rezanov, I. A., Rastvorova, V. A., and Leonov, N. N. Opyt detal'nogo seysmicheskogo rayonirovaniya na primere odnogo iz rayonov zapadnoy Turkmenii [Experience with detailed seismic regionalization exemplified by one of the regions of western Turkmenia]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 131-141, 1960.

After consideration of the structural geology, recent movements, and engineering-geologic conditions (all shown in sketch maps) of western Kopet-Dag in the Turkmen S. S. R., a detailed seismicity map was constructed for the region on a scale of 1:200,000. This map shows areas of high recent seismic activity and distinguishes places where the probability of secondary effects such as slumping, landslides, and cracks is highest. — D. B. V.

- 184-152. Riznichenko, Yu. V., and Nersesov, I. L. K razrabotke osnov kollektivnogo metoda seysmicheskogo rayonirovaniya [On working out the principles of a quantitative method of seismic regionalization]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 36-59, 1960.

One of the main tasks of the Tadzhik Joint Seismological Expedition of 1955-57 was to work out a method of detailed seismic regionalization on a scale of about 1:500,000 and to supplement the present methods of general regionalization on a scale of about 1:5,000,000 and microregionalization on a very much larger scale. The methods used in constructing a map for the Garm-Stalinalabad area, based on the relation between frequency of occurrence and energy,

are discussed. By means of quantitative geophysical calculations of the intensity of earthquakes, the amplitude-frequency spectrums of ground oscillations can be correlated with particular ground conditions.

These methods can also be used as the geophysical basis for micro- and general-regionalization. — D. B. V.

- 184-153. Nazarov, A. G., Karapetyan, B. K., Musayelyan, A. A., Piruzyan, S. A., Safaryan, A. N., and Shaginyan, S. A. *Predvaritel'nyye itogi raboty inzhenerno-seysmologicheskogo otryada TKSE v rayone g. Stalinabada* (Preliminary results of work of the engineering seismological detachment TKSE in the region of Stalinabad): Akad. Nauk Tadzhik. SSR Izv. Otdel. Yestestven. Nauk, no. 3 (30), p. 11-26, 1959.

A special detachment has been activated to work out methods of macroseismic, engineering geological, and seismometric investigation for seismic regionalization. Data on the earthquake of February 27, 1952, were reviewed, and the epicenter was found to be 15-20 km farther to the northeast of Stalinabad than had been indicated previously. Macroseismic and instrumental observations in the Stalinabad area demonstrate the presence of a so-called "seismic island" where the intensity of earthquakes is 1-2 points lower than in the rest of the city. — J. W. C.

- 184-154. Vvedenskaya, N. A. *K voprosu ob ispol'zovanii dannykh o slabykh zemletryaseniyakh dlya zadach seysmicheskogo rayonirovaniya* [On the question of the use of data on weak earthquakes in the problem of seismic regionalization]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 60-66, 1960.

Analysis of data on earthquakes in central Asia during 1950-56 shows that weak earthquakes are relatively more frequent in areas where strong earthquakes have occurred or occur today. This paper investigates the possibility of using weak earthquake data to delineate seismic zones. In zones where activity is steady, observations made by a stationary seismic network might be used; and in zones where activity is irregular, observations made by highly sensitive stations during relatively calm periods might be used to study earthquakes of very low energy levels.

It is concluded that observations of weak earthquakes by the present stationary network might be adequate to define seismic zones if used in conjunction with geologic data, but that as yet the problem of predicting maximum intensity and frequency of strong earthquakes on the basis of weak earthquake data demands more ample information than is available from the present network (see also Geophys. Abs. 173-40). — D. B. V.

- 184-155. Treskov, A. A. *Nekotoryye itogi seysmicheskikh issledovaniy v Priбайkal'ye* [Some results of seismic investigations in the Baikal region]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 5-10, 1960.

Historical records of earthquakes in the Baikal area of the Buryat-Mongol A. S. S. R., go back only 200-250 yr. Instrumental study is just beginning. Earthquakes as strong as 9-10 points occurred in 1742, 1814, 1862, 1950, 1957, and 1959. The seismicity of the southern part of the region is related to that of Mongolia; knowledge of earthquakes in the northern part is scanty.

The Irkutsk seismic station (established in 1912) was the only one in the Baikal region until 1951-52, when instruments were set up at Kaban and Kyakhta; in 1957 another station was established at Ulan-Bator in Mongolia. Others are planned for the near future. — D. B. V.

- 184-156. Florensov, N. A. Neotektonika Priбайkal'ya v svyazi s yego seysmichnost'yu [Neotectonics of the Baikal region in relation to its seismicity]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 11-20, 1960.

The evidence of recent intensive differential movements in the Baikal region is reviewed. As in other areas of recent mountain building, two basic types of deformation are distinguished, tilting of the basement surface and overlying Neogene cover and fracturing of the older and of Neogene-Quaternary structural groups. The present relief and structure of the Baikal region have been governed by the brittleness of the crystalline basement, which has led to fractures of different types, magnitudes, and ages. — D. B. V.

- 184-157. Bumasov, A. P. Magnitnoye i gravitatsionnoye polya Priбайkal'ya v svyazi s yego seysmichnost'yu [The magnetic and gravitational field of the Baikal region in relation to its seismicity]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 49-58, 1960.

The results of gravity and magnetic surveys in the Baikal region are discussed. The gravity anomalies indicate a thickening of the crust, which in places exceeds 70 km and is also reflected in the high relief of the area; this thickening is a manifestation of a reorganization of the crustal structure of the Caledonian Siberian platform that leads to high seismicity.

The magnetic anomalies are of two types: within the Irkutsk amphitheater (on the Caledonian platform) local anomalies of $+100\gamma$ to $+400\gamma$ that trend generally north-south are superposed on a positive regional background of $+200\gamma$ to $+300\gamma$, whereas in the folded area of the Baikal region linear positive anomalies stand out sharply against a negative regional background of -300γ to -500γ . The linear anomalies mark deep fractures (as much as 20 km deep) which divide the crust into blocks. These blocks are not isostatically compensated, and differential movements between them contribute to the high seismicity of the region. — D. B. V.

- 184-158. Solov'yev, S. L. K territorial'noye i statisticheskoy kharakteristike seysmicheskogo rezhime Priбайkal'ya [On the regional and statistical characteristics of the seismic regime of the Baikal region]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 65-72, 1960.

The distribution of earthquakes of different magnitude in space and time in the Baikal region is discussed. Since 1814 there have been 29 shocks of magnitude 5 or more; their epicenters are shown on a sketch map, and a table gives their dates, time, epicentral coordinates, magnitude (since 1912), and intensity (before 1912, and in some cases since). — D. B. V.

- 184-159. Petrushevskiy, B. A. K seysmogeologicheskoy kharakteristike gornyykh sooruzheniy yuzhnoy Sibirii i severnoy Mongolii [On the seismogeologic characteristics of the mountain structures of southern Siberia and northern Mongolia]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 108-120, 1960.

The seismogeologic conditions of the Baikal-Altai region and of northern Mongolia are examined in order to point out some features not previously described in the literature that are pertinent to an appraisal of the seismicity of different parts of the territory in question. Information is summarized in a table giving the time of stabilization; subsequent mobility in Mesozoic, Paleogene, and Neogene-Quaternary time; character of Neogene-Quaternary movements; significance of inherited development in recent structural plan; and seismicity. — D. B. V.

- 184-160. Aprodov, V. A. O neotektonike i seysmichnosti territorii Mongol'skoy Narodnoy Respubliki [On the neotectonics and seismicity of the territory of the Mongolian People's Republic]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 121-133, 1960.

"Neotectonics" is defined as crustal movements and their resulting structures which are actively manifested in the recent relief of a locality. In the seismic western part of Mongolia the major movements have been due to the continued development of the chief orographic elements in Quaternary and Recent time. The movements are of six orders of magnitude: polyregional continental uplift and subsidence, regional upwarping and downwarping; formation of block mountains and troughs, rampart-like bulging athwart rivers that disrupts the drainage network, local dislocations of river terraces and erosion surfaces, and formation of earthquake scarps and cracks. — D. B. V.

- 184-161. Natsag-Yum, L. Rel'yef Mongol'skoy Narodnoy Respubliki v svyazi s tektonikoy i seysmichnost'yu [Relief of the Mongolian People's Republic in relation to the tectonics and seismicity]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 134-140, 1960.

The whole territory of Mongolia lies in one of the active seismic zones of Asia. A hypsometric map of the country is given, on which have been plotted the locations of Quaternary volcanoes and earthquake epicenters distinguished according to magnitude. The different altitude groups differ in geomorphic features and geologic structure and in tectonic mobility and seismicity. Most deep and regional faults, which delimit structural-facies zones or separate orographic elements, are related to negative relief forms. Steep mountain slopes and linear step-like breaks in relief indicate incipient tectonic fractures. The higher mountain area in west and northwest Mongolia is more active seismically than the east and southeast part of the country; in the latter, earthquakes do not exceed 7 points in strength. — D. B. V.

- 184-162. Solonenko, V. P. O nekotorykh osobennostyakh zemletryaseniy Mongolo-Baykal'skoy seysmicheskoy zony [On some features of earthquakes of the Mongolo-Baikal seismic zone]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 141-147, 1960.

The Mongolo-Baikal seismic zone is one of the most extensive and most active in the world. Distinctive features are its intracontinental location and the great age of its structural elements. Focal depths are normal; those of strong earthquakes lie on regional fractures, mostly in zones with steep geologic and geomorphic gradients representing old structural lines that have been reactivated periodically.

The different types of seismogenic structures are described. The intensity of strong earthquakes is not felt uniformly about their epicenters but is influenced by local geologic conditions. A number of examples are given to illustrate this point. — D. B. V.

- 184-163. Rezanov, I. A. O noveyshey tektonike i seysmichnosti Severo-Vostoka SSSR [On very recent tectonics and seismicity of northeastern USSR]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 156-167, 1960.

Plio-Quaternary movements in the northeastern part of the U. S. S. R. show a variety of features. Uplift has taken place in two stages, at the beginning of the Pliocene and, more strongly, in the second half of the Quaternary. In spite of the considerable extent, the contrast in neotectonic movements has been negligible except in certain areas. Seismic activity is governed entirely

by the character of recent movements. High seismic activity corresponds either to the zones of contrasting movements or to areas where old structures have been reactivated. These facts are reflected in the 1957 seismicity map, which is reproduced for this region. A 7-point zone extends along the coast of the Sea of Okhotsk and northeastward into the Anadyr River basin; this is a zone of contrasting movements. It is possible that this 7-point zone should be extended somewhat to the north of Magadan to take in the whole zone of contrasting Plio-Quaternary movements. — D. B. V.

- 184-164. Li, Shan-Pan. Nekotoryye itogi seysmologicheskikh issledovaniy v KNR [Some results of seismological investigations in the Chinese People's Republic]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 149-155, 1960.

This is a review of results of recent seismological investigations in China, where rapid industrial expansion makes a knowledge of the regional and temporal distribution of earthquakes very important. Historical records are scanty before the 15th century. The distribution of known earthquakes since 1189 B. C., broken down into groups according to magnitude, is tabulated for the periods 1189 B. C. - O, A. D. 1-1000, 1001-1400, the 15th, 16th, 17th, 18th, and 19th centuries, 1901-30, and 1931-55. Three maps show the location of epicenters, the general structural plan, and seismotectonic lines in China.

Earthquakes are associated with young mountain areas, with boundary zones between major structural elements, and with zones of weakness within platform areas.

A stable, convenient, and highly sensitive seismograph that has been developed by the Chinese Institute of Geophysics and Meteorology for field use is described. So far it has been used near Peiping, but plans call for several such instruments in other parts of the country. — D. B. V.

- 184-165. Gorshkov, G. P. Voprosy seysmotektoniki i seysmicheskoye rayonirovaniye territorii Kitayskoy Narodnoy Respubliki [Problems of seismotectonics and the seismic regionalization of the territory of the Chinese People's Republic]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 7, 54 p., 1960.

Historical studies of earthquakes in China are based on nontechnical sources, catalogues of earthquakes, and the contemporary (since 1920) studies of individual earthquakes. The seismicity of China is reviewed, and a list of strong earthquakes recorded from 999 B. C. to A. D. 1955 is compiled for each province; the date, location, epicentral coordinate, and intensity (6-12 points) of 200 earthquakes are given. An epicenter map of China for the period from 1000 B. C. to A. D. 1954, for the period from 1906 to 1955 instrumentally recorded, and an isoseismic map for the period of 1000 B. C. to A. D. 1956 are given on separate sheets. — A. J. S.

- 184-166. International Geophysical Year Center. Seismological observations in Japan during the International Geophysical Year 1957-58 [in Japanese]: Zisin, ser. 2, v. 13, no. 1, p. 43-60, 1960.

The seismological observations in Japan during the International Geophysical Year are summarized in tables in English as follows: list of seismological stations with their location, foundation, and type of observations made; a list, for each station, of the seismographs and their constants; a chart of the destination of various data; and a list of seismograms recorded on micro-

film giving origin time, epicenter, location, depth, and magnitude for each earthquake. Maps are included to show (1) the distribution of the observation stations in Japan, and (2) the distribution of epicenters of earthquakes with $M > 6$ for the period of observation. — V. S. N.

- 184-167. Chao, Tsi-Chen. *Meteorologiya i seysmologiya v kitaye* [Meteorology and seismology in China]: Priroda, no. 10, p. 27-34, 1959.

Research in meteorology and seismology carried out by the Institute of Geophysics of the Academy of Sciences of the Chinese Peoples' Republic is discussed. Descriptions of more than 15,000 earthquakes in China are collected in a symposium entitled, "Chronological Tabulation of Chinese Earthquake Records." More than 8,000 references were investigated in preparation of this list. "The catalog of earthquakes in China" was based on the above symposium. The data were systematized and supplemented with the material of contemporary instrumental observations. The catalog contains information on 1,180 major earthquakes of the period from 1189 to 1955. First arrivals, epicenters, calculated intensity, and resulting destruction are given. Much seismic engineering work is being done, and construction of seismic instruments is on a large scale. — A. J. S.

- 184-168. Bolt, B. A. The revision of earthquake epicenters, focal depths and origin-times using a high-speed computer: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 433-443, 1960.

A program for an automatic computer has been developed to revise rapidly, provisional foci and origin-times of normal and deep-focus earthquakes. For each earthquake, up to 300 equations of condition found from P, pP, and PKP observations are solved by least squares to give a correction to the trial location. Special attention is given to the weighting of observation and factors affecting convergence. Features of the program are that the theoretical traveltime tables are stored in complete form, and after each iteration a list of stations with corresponding distances, azimuths, and residuals as well as the root-mean-square error is printed. Applications to a 1954 hydrogen bomb explosion and a number of earthquakes are described. The results suggest that the program may be useful to research organizations requiring either regular or special location of epicenters. — Author's summary

- 184-169. Treskov, A. A., and Medvedeva, G. Ya. *Kombinirovannyye metod opredeleniya gipotsentra* [Combined method of determination of a focus]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 46-48, 1960.

It has been assumed until now that observations from 4 seismic stations give only the minimum information necessary for determining the focus of an earthquake; and by using Wadati's method, a unique but uncontrolled solution is obtained. This view does not fit in with the fact that the arrival times of one of the phases (for instance the S-phase) and the $\bar{S}-\bar{P}$ differences are independent observational data. With the observations of 4 stations, there are 8 initial data for 6 relevant determinations of values as follows: 2 epicentral coordinates, depth of focus h , origin time t_0 , and 2 velocities (transverse, v , and imaginary, w , waves). This abundance of data provides a control of the solution.

An example is given, using the earthquake of February 22, 1952 in the northern Tien Shan where lines constructed on the basis of S-wave arrivals and $\bar{S}-\bar{P}$ differences at four stations intersect at a point. — D. B. V.

- 184-170. Mattern, G. Die Ortung ferner Erdbeben mittels seismischer Registrierung [Location of distant earthquakes by seismic registration]: *Geog. Rundschau*, v. 12, no. 11, p. 445-449, 1960.

The various types of seismic waves generated by earthquakes and the method of determination of the focus are discussed for the nontechnical reader. — J. W. C.

- 184-171. Iida, Kumizi. Earthquake energy and earthquake fault: *Nagoya Univ. Jour. Earth Sci.*, v. 7, no. 2, p. 98-107, 1959.

The results of an investigation of earthquakes in Japan and in other parts of the world that have been accompanied by some degree of fault breakage at the earth's surface are reported. Observation of fault breakage is an important aid in studying the earthquake-generating mechanism, the nature of the earth's crust, and the energy release patterns in the earth's crust.

The smallest earthquake for which surface effects have been observed is of the magnitude $M=5.6-5.7$; this also corresponds to the smallest shock accompanied by crustal deformation and tsunami. In Japan, earthquakes with a magnitude >7.3 are always accompanied by faulting. The amount of vertical and horizontal displacement of the earthquake fault is generally about 2-4 m, rarely 7-8 m, and not over 8 m. The greatest length observed for an earthquake fault is 435 m. A series of empirical equations is presented to show the relationship between earthquake magnitude and fault length in order to derive earthquake energy from the fault data of Japan and other parts of the world. Results suggest that energy released in the larger shallow earthquakes is approximately proportional to the fault length and to the area at the earth's surface of the zone of initially strained rock. — V. S. N.

- 184-172. Aki, Keiiti. Further study of the mechanism of circum-Pacific earthquakes from Rayleigh waves: *Jour. Geophys. Research*, v. 65, no. 12, p. 4165-4172, 1960.

The source functions of three western Pacific earthquakes (June 25, 1958; July 18 and 27, 1959) were obtained from Rayleigh waves recorded at many International Geophysical Year stations throughout the world, and analyzed by a method proposed in a previous paper (see *Geophys. Abs.* 182-117). It was found that the pattern of the force at the source is quadrant for all three earthquakes, in accordance with the model adopted in the fault plane studies. One of the two nodal lines is nearly parallel to the trend of the seismic zone for each of these earthquakes. If this nodal line is taken as the fault, the slip directions are right hand in all three cases. The result from the recent Chilean shocks also supports the hypothesis that right-hand strike-slip prevails along the circumpacific earthquake belt. — D. B. V.

- 184-173. Ritsema, A. R. Focal mechanisms of some earthquakes of the year 1950: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 307-313, 1960.

Fault plane solutions are given for 15 earthquakes that occurred in 1950. The data used for this study were the compressions and dilatations of P and PKP listed in the International Seismological Summary for 1950, supplemented by information on initial motion directions of these waves furnished by seismic stations in the zones relevant to the determination. The results show a predominance of transcurrent fault motions at earthquake focuses over reverse and normal fault motions, confirming earlier results (see *Geophys.*

Abs. 178-67 through 178-75). The A- and C-axes also show a preference for directions that are about perpendicular to and parallel with the seismic zones in which the earthquakes take place. — D. B. V.

- 184-174. Oulianoff, Nicolas. Tassements et effondrements dans les séries sédimentaires [Packing and subsidences in sedimentary formations]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 1, p. 115-116, 1960.

Perpetual vibration of the earth's crust has been shown to cause accumulation of bodies of fossil water under impervious clay layers in sedimentary basins. When the sediments are fractured as a result of tectonic activity, the water escapes upward and leaves voids. Where the sum total of these voids becomes appreciable the overlying rock settles, producing a depression at the surface. The process is capable of generating earthquake shocks, in a manner analogous to the tremors caused by settling near coal mining excavations but on a much larger scale. — D. B. V.

- 184-175. Vvedenskaya, A. V., and Balakina, L. M. Metodika i rezul'taty opredeleniya napryazheniy, deystvuyushchikh v ochagakh zemletryaseniy Pribaykal'ya i Mongolii [Methods and results of determination of strains operating at the focuses of earthquakes of the Baikal region and Mongolia]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 73-84, 1960.

After a description of the method used, fault plane solutions are worked out and presented in stereographic diagrams for the earthquakes of June 27, 1957, January 5, 1958, and September 14, 1958 in the southeastern Baikal region; April 4, 1950, February 6, 1957, and June 23, 1958 in the southwestern Baikal region and the Selenga River basin; and December 4, 1957 in Mongolia. P- and S-wave data from seismic stations in the Russian Far East region and central Asia were used. — D. B. V.

- 184-176. Laclavère, G. Can we forecast and protect ourselves against earthquakes: Impact, v. 10, no. 4, p. 217-229, 1960.

The losses caused by earthquakes with reference to some of the major earthquakes on record are reviewed, and the international organization of seismological studies is described briefly. The need for an even distribution of seismological stations throughout the world is emphasized. The causes and frequency of earthquakes are discussed and our inability to predict them is admitted; it is shown how some degree of protection against their destructive effects may be attained by determining the degree of seismic activity in various regions and by erecting shock-resistant buildings. The tidal-wave warning system in the Pacific area is explained briefly and the relationship between earthquakes and volcanoes discussed. A program of fundamental seismic research is outlined. — V. S. N.

- 184-177. Lyamzina, G. A. Ob opredelenii seismicheskikh svoistv gruntov pri promoshchi peredvizhnoy seismicheskoy stantsii [On determination of seismic properties of grounds with the aid of a portable seismic station]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 141-152, 1960.

The effects that grounds of certain properties can exert on the intensity of oncoming seismic waves were studied, and an attempt made to determine the

rigidity of grounds and the periods of their natural oscillations. Amplitudes increase suddenly up to 2-3 points intensity when the seismic waves acting on the ground coincide with the period of natural oscillation of the ground. A portable seismic station was devised to study ground rigidity and elasticity for seismic microregionalization in the northwest Caucasus. — A. J. S.

- 184-178. Tan, Go-Tsyuan. O primeneni teorii veroyatnostey v zadachakh inzhenernoy seismologii [On application of the theory of probability to problems of engineering seismology]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 99-104, 1960.

The necessity is demonstrated for applying the probability method to solution of problems in engineering seismology arising from the fact that ground movements of earthquakes are not definite functions of time. — A. J. S.

- 184-179. Kats, A. Z. O kharaktere kolebaniy nekotorykh zhestkikh massivnykh sooruzheniy pri rasprostraneni seysmicheskikh voln [On the character of oscillations of certain rigid massive constructions acted upon by propagating seismic waves]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 175-181, 1960.

The problem of vibrations of a rigid massive structure carrying a load of an installation that has a rapidly rotating mass is considered. It is shown that additional gyroscopic moments appear in the rotating system effected by seismic movements of the ground, and that such additional moments can disturb the normal working rate of the system. Some experimental data are provided that characterize this phenomenon. — Author's abstract, A. J. S.

- 184-180. Korf, M. G. Primeneniye materialov seysmometrii k raschetam sooruzheniy na seysmicheskiye vozdeystviya [Application of seismometric data to construction designs for seismic effects]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 182-188, 1960.

Earthquake-resistant design of buildings is discussed on the basis of actually observed earthquake accelerograms. Effects of plasticity and elasticity of the ground are taken into account. The earthquake spectrum is determined by the graphic-analytical method (see Geophys. Abs. 168-23), and pendulum displacements of the seismometer calculated by the theory of probability. It is proposed that the method of successive integration of the differential equations of ground oscillations be applied instead of the graphical-analytical method. — A. J. S.

- 184-181. Murata, K. J. Vigil for disaster: Geotimes, v. 5, no. 5, p. 12-13, 1961.

An account is given of the tsunami generated by the Chilean earthquake beginning on May 21, 1960, that arrived in Hilo Bay, Hawaii, with destructive force early on May 23. The main wave, a 20-ft wall of water, demolished about half of the business district of Hilo, obliterated an older part of the city, and moved basaltic boulders weighing as much as 10 tons inland for a distance of more than 300 feet. The wave approached Hawaii at a speed of almost 500 mph. — V. S. N.

- 184-182. Écollan, Jean, and Rocard, Yves. Signaux microbarographiques en rapport avec les grands séismes du Chili [Microbarographic sig-

nals corresponding to the great earthquakes in Chile]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 4, p. 523-525, 1960.

On May 22, 1960, four microbarographic stations in France registered rather regular trains of acoustic waves of 25-sec period and 10-barye amplitude. It is suggested that these waves were atmospheric ripples provoked when the tsunami from the Chilean earthquake of May 21 impinged on the eastern Asiatic coasts. Rayleigh waves recorded an hour before the microbarographic signals by long-period seismographs at one of the four stations were related to the May 22 earthquake. Although Rayleigh waves coupled to the atmosphere are known, the signals in question are not believed to be of such origin. — D. B. V.

- 184-183. Alterman, Z., Jarosch, H., and Pekeris, C. L. Oscillations of the earth: Royal Soc. [London] Proc., ser. A, v. 252, no. 1268, p. 80-95, 1959.

Free and forced oscillations of the earth have been studied. The natural periods are determined for radial, torsional, and spheroidal types of oscillation, using five different earth models (homogeneous earth; homogeneous solid mantle enclosing homogeneous liquid core; Bullen's model B; and Bullard's models I and II). It is found that the second order spheroidal oscillation has a period of 53.5 min in all but the homogeneous earth model, in which it is only 44.3 min; the 53.5-min period agrees within observational error with the 57-min period observed by Benioff in the Kamchatka earthquake. Bullen's model B also has a second order spheroidal oscillation of about 101-min period, mainly in the core. Benioff's observation of an oscillation of 100-min period might be considered as evidence favoring this model; but it is calculated that the amplitude of the 100-min oscillation should be more than 1,000 times weaker than that of the 53.5-min oscillation, and thus it is not clear how a near-surface earthquake could have excited the core oscillation.

The spectrum of the free modes of oscillation has also been determined for $n=3$ and 4, including the fundamental and first two overtones for each case. The computed free periods of spheroidal oscillation range from 53.5 to 8 min for the fourth overtone in the case $n=2$. Love's numbers were also determined for Bullen's and Bullard's models in the case $n=2$ for bodily tidal periods of 6 h, $6\sqrt{2}$ h, 12 h, and ∞ . Dependence of the Love numbers on period is small; maximum range of variation (13 percent) occurs in the K -values between 6 h and ∞ . — D. B. V.

- 184-184. Alterman, Z., Jarosch, H., and Pekeris, C. L. Propagation of Rayleigh waves in the earth: Rehovot, Israel, Weizmann Institute, Department Applied Mathematics, 11 p., 1961.

The propagation of Rayleigh waves in the earth is investigated in the whole range of periods T from about 10 sec up to 1 hr. Three methods are necessary to cover this range of periods effectively. The standard flat earth method, with neglect of gravity, gives values for phase velocity C correct to within 1 percent up to $T=50$ sec and for group velocity U up to $T=250$ sec. The flattening of the earth method, with neglect of gravity, has accuracy limits of 1 percent for C and U at 300 and 400, respectively; inclusion of gravity effects does not alter the limits. For $T>300$ ($n<25$) the period of $T(n)$ of free oscillation of the earth as a function of the order of the spherical harmonic n must be determined; this involves solution of a system of differential equations of the 6th order in which gravitational effects are included. Using these three methods, $C(T)$ and $U(T)$ are evaluated for Bullen's model B, the Jeffreys-Bullen model as modified by Dorman, Ewing, and Oliver, and the Gutenberg model. Results substantiate conclusions that the observed Rayleigh

wave data provide evidence in support of Gutenberg's low velocity layer. The few observed Rayleigh group velocities between $T=400$ and 600 are substantially lower than the theoretical values for all three models. — V. S. N.

- 184-185. Benioff, Hugo, Press, Frank, and Smith, Stewart. Excitation of the free oscillations of the earth by earthquakes: *Jour. Geophys. Research*, v. 66, no. 2, p. 605-619, 1961.

The free oscillations of the earth have been experimentally verified from an analysis of strain seismograph and pendulum seismograph recordings made in California and Peru from the great Chilean earthquake of May 1960. Both spheroidal and torsional oscillations were revealed by a power spectral analysis of the seismograms. The gravest spheroidal mode shows a split spectral peak with periods of 54.7 and 53.1 min; the theoretical prediction by Alterman and others for the Bullen B model is 53.7 min (see *Geophys. Abs.* 184-183). The oscillations were observed for all modes up to 38 with corresponding periods as short as 3.7 min. In almost all cases agreement between experimental and theoretical predictions is close; the differences that occur should make it possible to discriminate between proposed earth models.

The dissipation function Q^{-1} for the earth is 380 for the spheroidal mode S_3 ($T=35.5$ min) and 170 for the mode S_{18} ($T=6.2$ min). If Q is independent of frequency, this implies a higher Q in the core than in the mantle.

A method is described for deducing the fault length and rupture velocity from analysis of phase difference between components of ground motion. Preliminary results indicate a fault length for the Chilean earthquake of about 1,000 km and rupture velocities in the range 3-4 kmps. — D. B. V.

- 184-186. Ness, Norman F., Harrison, John C., and Slichter, Louis B. Observations of the free oscillations of the earth: *Jour. Geophys. Research*, v. 66, no. 2, p. 621-629, 1961.

Free oscillations of the earth excited by the Chilean earthquakes of May 1960 were recorded with high precision at Los Angeles by a LaCoste-Romberg tidal gravimeter. Spectral analysis of the records shows that the spheroidal modes of type ${}_0S_l$, where $l=2, 3, 4, \dots, 40, 41$ were excited at periods in almost all cases within 1 percent of theoretical predictions of Alterman and others based on the Gutenberg earth model (see *Geophys. Abs.* 184-183). The first and second overtones for several modes were also identified. The Gutenberg model is in slightly better accord with the observations than the Bullen B model.

Upper and lower limits of the dissipation functions (Q) of these modes have been derived. These are generally of the order of 200 to 400; but the fundamental dilatational mode ${}_0S_0$ with a period of 20.46 min, for which shear stresses are absent, has a Q of at least several thousand and was observed even during quiet periods a month after the Chilean earthquakes. Three of the low-order modes are split, an effect which is ascribed to the earth's rotation. — D. B. V.

- 184-187. Alsop, Leonard E., Sutton, George H., and Ewing, Maurice. Free oscillations of the earth observed on strain and pendulum seismographs: *Jour. Geophys. Research*, v. 66, no. 2, p. 631-641, 1961.

Spectral analyses of seismograms of the great Chilean earthquake of May 22, 1960, from a strain seismograph at Ogdensburg, N. J., and from pendulum seismographs at Palisades, N. Y., have revealed peaks corresponding to fundamental spheroidal modes 2 to 34, fundamental torsional modes 2 to 9, and the first overtone of the second spheroidal mode.

The periods of the graver modes of oscillation, both spheroidal and torsional, are in agreement with the theoretical values of Alterman and others (see

Geophys. Abs. 184-183). The periods of the fundamental spheroidal oscillations between 250 and 500 sec show excellent agreement with theoretical values calculated for a mantle with velocities according to the Gutenberg model and densities according to the Bullen model A, and the torsional periods also agree well with theoretical values calculated from Jeffreys' velocities and densities of Bullen's model A (see Geophys. Abs. 182-159, -160). — D. B. V.

184-188. Bogert, B. P. An observation of free oscillations of the earth: Jour. Geophys. Research, v. 66, no. 2, p. 643-646, 1961.

The more extensive measurements by Benioff and others (see Geophys. Abs. 184-185, -186, -187) are supported by the results of spectral power analyses, using an electronic computer, of seismograms of the Chilean earthquake of May 1960, by a Columbia long-period vertical seismometer installed at Chester, N. J. Agreement is particularly good in the shorter period range (up to 17.7 min). It is suggestive that peaks at 20.4 and 10.06 min correspond to the lowest purely radial mode ${}_0S_0$ and the next lowest mode ${}_1S_0$, respectively. — D. B. V.

184-189. Pekeris, C. L., Alterman, Z., and Jarosch, H. Comparison of theoretical with observed values of the periods of free oscillation of the earth: U.S. Natl. Acad. Sci. Proc., v. 47, no. 1, p. 91-98, 1961.

The periods of free oscillations up to order $n=61$, calculated for two earth models—Bullen B and Gutenberg—are tabulated and compared with the periods of free oscillations from the Chilean earthquake of May 1960 as observed by strain and pendulum seismographs (see Geophys. Abs. 184-185) and tidal gravimeter (see Geophys. Abs. 184-186).

The periods deduced from power-spectra analysis of the seismic and gravimeter records agree to within 1 percent. The periods of spheroidal oscillations for the Gutenberg model agree with observed values to within 1 percent, and this is true also for the Bullen B model at periods less than 5 min. In the period range of 5-11 min the Bullen B values are systematically about 2 percent higher than the observed values. Torsional oscillations, recorded only in the seismograms, agree to within 1 percent with both models except for the $n=1$ mode, which was weakly recorded. An order-of-magnitude argument is presented in support of the hypothesis of the rotational origin of the frequency splitting of the free oscillations of the earth. — D. B. V.

184-190. Slichter, Louis B. The fundamental free mode of the earth's inner core: U.S. Natl. Acad. Sci. Proc., v. 47, no. 2, p. 186-190, 1961.

The Chilean earthquake of May 22, 1960, furnished the first fully convincing observational evidence concerning the free modes of oscillation of the earth. More than 40 free modes were identified in spectral analysis of tidal gravimeter observations (see Geophys. Abs. 184-186), each at a peak corresponding to theoretical predictions (see Geophys. Abs. 180-189). However, the first spectral peak (about 86-min period) appearing at the low end of the spectrum was not theoretically predicted; this peak also occurred in the spectral analysis of several of the subintervals of the 4.6-day gravimeter record, and significantly it is absent in analysis of the quiet period a month later.

It is suggested that a gravitational perturbation of the approximate observed magnitude (0.64 microgal) and period could be produced by oscillations of the inner core as a rigid body in the surrounding fluid core. This mode would escape detection by a strain meter because no first-order strain would be associated with such rigid body displacements. Results of some calculations concerning the dynamics of the mode are summarized here.

Study of this inner core oscillation provides new observational evidence about the center of the earth. The development of information concerning the physical properties of the outer core from studies of the core-mode should assist in identifying the material of the core. By this means, the mechanical properties of the core can be studied under conditions not obtainable in the laboratory (pressures of several million atmospheres and temperatures of about 4,000°C). — D. B. V.

- 184-191. Northrop, John, Blaik, Maurice, and Tolstoy, Ivan. Spectrum analysis of T-phases from the Agadir earthquake, February 29, 1960, 23h 40m 12s GCT, 30° N., 9° W. (USCGS): *Jour. Geophys. Research*, v. 65, no. 12, p. 4223-4224, 1960.

T-phases from the Agadir, Morocco, earthquake were recorded from several SOFAR-type bottomed geophones. The recordings were then examined with spectrum analysis equipment of a few cycles per second resolution. Tracings of the T-phase arrival at three stations are reproduced; they show a considerable amount of dispersion in the signal, giving it a "Christmas-tree" shape that has been observed before but never correlated definitely with the T-phase. The early branches of the "tree" correspond to the velocity maximum and the "peak" to the "rider" wave of Pekeris (1948); the "stem" shows the beginning of the Airy phase (see *Geophys. Abs.* 181-124). The trailing edge varies considerably from station to station and is probably due to reverberation, local excitation, and the arrival of later modes including the Rayleigh mode. The velocities computed for T are 1.49 ± 0.005 km/s for all paths.

This is probably the first time the T-phase has been observed from a transatlantic earthquake. From a detailed study of the spectrum of such T-phases it may be possible to determine the parameters of the travel path—sediment thickness and velocity, holes in the mid-Atlantic ridge that passed T-phase energy, and refraction of rays toward the lower-velocity northern water paths.

Frequency analysis of T-phases may also provide a way to distinguish between earthquakes and atomic blasts (see *Geophys. Abs.* 179-95). In the present paper it is apparent that the later modes form a characteristic of the signal; a T-phase signature like this would probably not be excited by surface bomb explosions. — D. B. V.

- 184-192. Herrin, Eugene. On \bar{P} and L_g : *Jour. Geophys. Research*, v. 66, no. 1, p. 334-335, 1961.

The results obtained by Herrin and Richmond in their paper on propagation of the L_g phase (see *Geophys. Abs.* 183-155) contain an error concerning the partitioning of energy between Sv- and P-waves. This error is corrected and the revised results tabulated, and the propagation of $\bar{P}(\Pi_g)$ phases recently reported by Shurbet (see *Geophys. Abs.* 182-125) is analyzed in their light. Only the sedimentary basin model in the table would allow propagation of P-waves within the L_g wave guide; for all other models there is almost complete transformation from P to Sv at the free surface, resulting in high amplitude L_g but no detectable $\bar{P}(\Pi_g)$. — D. B. V.

- 184-193. Bullen, K. E. Note on cusps in seismic travel-times: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 354-359, 1960.

When there is triplication in traveltime curves, it is often assumed that the cusps in the curves are necessarily associated with large wave amplitudes. Models that give a good representation of various types of seismic velocity variation are here set up to show that there are important cases in which this assumption does not apply. The analysis, which is facilitated by use of the

variable $\alpha = 2d \log r / d \log \eta$ (where $\eta = r/v$, v = velocity at distance r from the center of the earth model), shows fairly directly that $d\Delta/dp$ (where Δ and p are the angular length and parameter of ray) is sometimes discontinuous, sometimes continuous, at a cusp. — D. B. V.

MacDowall, J. Some observations at Halley Bay in seismology, glaciology, and meteorology (with discussion). See Geophys. Abs. 184-

- 184-194. Choudhury, Mansur Ahmed. PKP₂ et ses réflexions à l'intérieur de la croûte terrestre [PKP₂ and its reflections in the interior of the earth's crust]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 3, p. 407-409, 1960.

Longitudinal PKP₂ waves that have been reflected twice at the inner boundary of the crust can be recognized in the records of deep earthquakes. A crustal thickness of 30 km is calculated from these waves in the records of 10 deep ($h=100-600$ km) earthquakes in Fiji, Tonga, and the Kermadec Islands, obtained in 1958-60 at the Garchy seismic station in France. — D. B. V.

- 184-195. Magnitskiy, V. A., and Khorosheva, V. V. K voprosu o volnovode v obolochke zemli i yego fizicheskoy prirode [On the problem of the wave guide in the earth's mantle and its physical nature]: Akad. Nauk SSSR Doklady, v. 135, no. 2, p. 305-307, 1960.

Using data obtained at seismic stations in the U. S. S. R. for nine earthquakes at epicentral distances chosen so that there would be no overlapping of other information with the phases sought, waves propagating in wave guides in the mantle were investigated. The velocities obtained for P_a and S_a are 8.30 ± 0.03 km/s and 4.57 ± 0.03 km/s and their periods are 5-12 sec and 7-30 sec, respectively. The results show clearly that these waves are cylindrical in nature. The velocity values preclude the possibility that they are surface waves or Stoneley waves, and they propagate only in the wave guide. Quantitative calculations show that the data are compatible with the old hypothesis that the material of the low velocity layer is amorphous. — D. B. V.

- 184-196. Ogurtsov, K. I. Otsenki intensivnostey seysmicheskikh voln, otrazivshikhsya ot ochen' slablykh granits razdela [Evaluations of intensities of seismic waves reflected from very weak interfaces]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1426-1431, 1960.

A mathematical analysis is made of the intensities of reflected waves in a seismic vertical ray. Both the zero (acoustic) approximation and the first term of the asymptotic series representing the solution are taken into account. It was found that in evaluation of intensities of seismic waves reflected from very weak interfaces the first term of the asymptotic series must be taken into consideration, since the zero approximation may be totally absent, be very small, or of the same magnitude as the first asymptotic term. — A. J. S.

- 184-197. Popov, I. I. O dispersii dlinooperiodnykh voln Lyava v kontinental'noy i okeanicheskoy kore na trassee Indoneziya—Krym [On the dispersion of long-period Love waves in the continental and oceanic crust on the Indonesia-Crimea traverse]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1458-1462, 1960.

Results of an experimental investigation of long period Love waves from the earthquake of August 12, 1958, at 19^h25^m05^s in the region of the Molucca Sea ($\phi=0^\circ$, $\lambda_E=126^\circ$) recorded at the Simferopol seismic station are discussed.

The mean thickness of the oceanic crust along the track of Molucca Islands, Arafura Sea, northeastern coast of Australia, New Zealand, and the Pacific Ocean was calculated to be 15 km, and that along the continental track of southwestern China, Himalayas, Tibet, Pamirs, Turanian Lowland, Caspian Sea, and northern Caucasus to be about 40 km. The energy absorption coefficient of the Love waves was found to be 0.00023. — A. J. S.

- 184-198. Khoroosheva, V. V. Nekotoryye rezul'taty issledovaniya voln P_a i S_a po seysmogrammam stantsiy SSSR [Certain results of investigation of P_a and S_a waves according to seismograms of U. S. S. R. stations]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1563-1569, 1960.

P_a and S_a seismic waves recorded at stations in the U. S. S. R. were investigated. The approximate magnitude of the index of geometric divergence (about $\frac{1}{2}$) and the absorption coefficient (0.000144 per km on the average) of the P_a waves were obtained. The traveltime curves of P_a and S_a are found to be linear, and the velocities are $8.30(\pm 0.03)$ and $4.57(\pm 0.03)$ km/sec, respectively. The linearity of the traveltime curves of the waves, their velocities, and the range of their propagation support the existence of a wave guide at the upper level of the earth's mantle. P_a and S_a waves were found not only from earthquake foci in the waveguide, but also from foci 50 to 640 km deep. — A. J. S.

- 184-199. Bulin, N. K., and Tryufil'kina, Ye. I. Ispol'zovaniye obmennykh voln SP, registriruyemykh pri blizkikh zemletryasenyakh, dlya izucheniya glubinnogo stroeniya zemnoy kory [Utilization of transformed SP waves recorded from local earthquakes for study of deep structure of the earth's crust]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1570-1579, 1960.

The problem of distinguishing transformed SP waves on seismograms of local earthquakes is discussed. The method of interpretation of SP records is explained, and the results of such interpretations in connection with studies of crustal structure in southeastern Turkmen S. S. R. are reported. The method can be used in the regions not more than 1,000-1,500 km from the epicenter of the earthquake. — A. J. S.

- 184-200. Medvedev, S. V. Uskoreniya kolebaniya grunta pri silnykh zemletryasenyakh [Accelerations of ground oscillations in connection with strong earthquakes]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 32-89, 1960.

Accelerograms of 124 strong earthquakes (5-8 points) are reproduced and the method of their recording is explained. These accelerograms are interpreted, and the values of acceleration in ground oscillations due to earthquakes of various intensities and oscillation periods are calculated and presented in tables. — A. J. S.

- 184-201. Puchkov, S. V. Nekotoryye voprosy instrumental'nogo opredeleniya reologicheskikh svoystv gruntov na osnove rasprostraneniya seismicheskikh voln [Certain problems of instrumental determination of rheologic properties of grounds on the basis of seismic wave propagation]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 118-132, 1960.

In accordance with Maxwell's concept, the ground is considered as an elastic-plastic medium. A theory of seismic-wave propagation is developed for such a medium. Differential equations of motion are derived, and formulas for travel velocity of longitudinal and transverse waves developed, along with correlations that permit a determination of attenuation coefficients and relaxation time of the medium. The formulas obtained were applied by the Baikal Region Expedition to the evaluation of seismic records. — Author's abstract, A. J. S.

- 184-202. Korf, M. G. Otsenka inzhenernykh kharakteristik zemletryaseniya metodami matematicheskoy statistiki [Evaluation of engineering characteristics by the method of mathematical statistics]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 133-140, 1960.

A statistical method is proposed to evaluate the occurrence probability of seismic spectrums; this method is similar to one that has been used successfully to estimate river discharge. An example is treated in which several published spectra are used. — A. J. S.

- 184-203. Karapetyan, N. K. Nekotoryye osobennosti zapisi zemletryaseniya Malogo Kavkaza [Several features of the record of earthquakes of the Lesser Caucasus]: Akad. Nauk Armyan. SSR Izv., v. 12, no. 6, p. 57-62, 1959.

On the records of near earthquakes the arrivals of known waves are often accompanied by arrivals the nature of which has not been understood. The equipping of most of the Caucasus seismic stations with a single type of broad-band (Kirnos) apparatus has made it possible to use correlation principles in clarifying these unknown waves. Such an arrival, recorded for the February 2, 1953 Lesser Caucasus earthquake, is interpreted as a PPS wave. This wave emerged from the focus as a longitudinal type, was reflected from the surface, propagated along the basalt-ultrabasalt interface (still longitudinal), and finally passed to the surface as a transverse type. — J. W. C.

- 184-204. Bolt, Bruce A. Revision of earthquake epicenters and seismic traveltime curves using the IBM 704 computer: Earthquake Notes, v. 31, no. 3, p. 25-26, 1960.

A program, coded for the IBM 704, is designed to reduce to a minimum by a least-squares method the differences between observed P traveltimes and P traveltimes calculated from standard tables. — V. S. N.

- 184-205. Melton, Ben S. Useful concepts for the engineering design of seismographs: Earthquake Notes, v. 31, no. 3, p. 26-27, 1960.

The important conclusions resulting from theoretical and experimental studies of electromagnetic seismographs are listed. They are given without proof to indicate the present possibilities and advisable practices that can lead to good seismograph design. — V. S. N.

- 184-206. Banerjee, K. N. Response characteristics of electromagnetic seismographs: India Natl. Inst. Sci. Proc., v. 26, pt. A, no. 4, p. 348-354, 1960.

A mathematical analysis is presented for the response characteristics of an electromagnetic seismograph associated with a combination of damped and sustained harmonic displacement of the ground. The seismometer and gal-

vanometer have been assumed to have initial motions. Numerical results show clearly that the magnitude as well as the direction of the initial motions of the seismometer and galvanometer play an important part in the nature of records obtained in seismograms; in many cases the recorded trace may be quite different from the ground motion. If the contributions of the initial motions of the seismometer and galvanometer and of the transient part of the response are taken into consideration in the interpretation of seismograms, the relationship between the amplitude in the seismogram and the extent of energy released at the hypocenter will be better understood. — V. S. N.

- 184-207. Duclaux, F[rançoise]. *Séismométrie théorique* [Theoretical seismometry]: Paris, Gauthier-Villars, 129 p., 1960.

This book consists of the following chapters: general principles of pendulum seismographs, horizontal pendulum, vertical pendulum, horizontal seismograph with mechanical amplification, standardization of a seismograph with mechanical amplification, general theory of electromagnetic seismographs, response of the electromagnetic seismograph to sinusoidal movements and to abrupt movement of the ground, apparatus without equivalent reaction to a given apparatus, principal types of electromagnetic seismographs, calculations of an apparatus having given properties, standardization of an electromagnetic seismograph, verification of standardization and functioning of an electromagnetic seismograph, and various questions of adjustment. — J. W. C.

- 184-208. Berckhemer, Hans, and Hiller, Wilhelm. *Kurzperiodische Stationsseismographen mit Trägerfrequenzverstärker und mechanischer Registrierung* [Short-period station seismographs with carrier-frequency amplifier and mechanical recording (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 1, p. 1-8, 1960.

A new short-period seismograph system developed at Stuttgart, Germany, is described. The pendulum has a mass of 1 kg and a natural period of 1-1.5 sec. The mechanical displacement is converted into electric signals by means of variable inductances which form the branches of an a-c current bridge. This bridge is fed by a current of 50 cycles per second taken from a power line or from a transistor oscillator. An amplifier with 3 transistor stages and phase discriminator drives a pen motor of differential moving-coil type, recording on smoked paper. All three components are tuned naturally. Maximum magnification is adjustable between 3,000 and 40,000. The seismograph operates mainly as a displacement meter. The exact solution and an approximation of the dynamic magnification function are given. A schematic diagram and photographs illustrate the text. — D. B. V.

- 184-209. Heidrich, Werner, and Just, Heinz. *Die Rückwirkung von Schwingungsmessgeräten auf das Messergebnis in der Bodendynamik* (The reaction of vibration measuring devices on the results of measurements in ground dynamics): *Freiberger Forschungshefte*, C 81 *Geophysik*, p. 33-43, 1960.

In the measurement of ground motions in both seismology and seismic surveying it has been established that certain instruments, such as seismometers, may react preferentially to frequencies that are not their natural frequencies as determined in the laboratory. This is due to the fact that the motion recorded by any vibration measuring device that is placed on the ground is not the true ground motion, but the ground motion plus the motion of the instrument itself; the latter lags behind the ground motion slightly as a result of the mass inertia of the instrument. This paper shows how the distortion

can be estimated so as to obtain the true vertical ground motion. The corresponding distortion in the case of a horizontal seismometer can be calculated similarly. In that case, however, the coupling to the ground plays an important role so that general equations are less significant. Five pages of diagrams are given for calculating the effect of the inertia of masses of circular basal section on a harmonic elastic wave field. — D. B. V.

- 184-210. Arkhangel'skiy, V. T. Voprosy teorii dlinnoperiodnogo vertical'nogo seysmometra [Problems of the theory of the long-period vertical seismometer]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1432-1441, 1960.

The theory of pendulum suspension for a vertical seismometer is discussed, and the fundamental terms in the equation of motion of the pendulum that cause its instability when the period is increased are denoted. From the differential equation of the pendulum of a vertical seismometer, the period of natural oscillation of the pendulum and the basic factors of its stability are derived. Variants of the pendulum suspension are suggested that would eliminate "limping" of the natural oscillations, and methods are proposed for obtaining a large oscillation period of the pendulum. — A. J. S.

- 184-211. Moskvina, A. G., and Shebalin, N. V. Primeneniye seysmografa s dvumya gal'vanometrami dlya odnovremennoy zapisi zemletryaseniya na dvukh urovniyakh chuvstvitel'nosti [Adaption of a two-galvanometer seismograph for simultaneous recording of earthquakes on two sensitivity levels]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1474-1478, 1960.

An automatic device for desensitizing seismographs when the amplitude of a recorded earthquake wave is greater than the recording capacity of the apparatus is discussed. Automatic systems that switch on and shunt the stronger signals are found unsatisfactory because of inertia during the initial change in the motion of their galvanometer (see also Geophys. Abs. 146-12932, 165-67). An automatic system of two galvanometers operating at two sensitivity levels is discussed (see also Geophys. Abs. 167-163). It was found that this system is practically free of the defects of the shunting galvanometer. A sample seismogram of the new apparatus is given. — A. J. S.

- 184-212. E, Shi-Yuan. Sposoby registratsii kolebaniy grunta pri silnykh zemletryaseniyakh [Recording methods of ground vibrations due to strong earthquakes]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 10 (177) (Voprosy inzhenernoy seysmologii no. 3), p. 105-111, 1960.

A description of seismic devices for recording of accelerations and displacements of ground during strong earthquakes is presented chronologically from 1880 to 1955. — A. J. S.

- 184-213. Gayskiy, V. N. O tochnosti opredeleniya uglov s pomoshchyu azimuthal'noy ustanovki s naklonnymi seysmografami [On the accuracy of determination of angles by means of an azimuthal setup with inclined seismographs]: Akad. Nauk Tadzhik. SSR Inst. Seysmologii Trudy, v. 71, no. 2, p. 39-45, 1957.

The accuracy of determination of the azimuth and angles of propagation of seismic rays by means of an inclined seismograph is investigated. A series of formulas is derived for computation of errors due to distortion by the in-

struments. A comparison is made between the errors of the conventional three-component installation and those of a four-component installation with an inclined apparatus. — J. W. C.

184-214. Earthquake Notes. Recent seismic events: Earthquake Notes, v. 31, no. 3, p. 34-36, 1960.

A brief description is given of the planned expansion of the Canadian government seismograph network, of the new seismological observatory at Honiara, Guadalcanal, and of the seismological stations and program of the government of Finland. — V. S. N.

Savarenskiy, Ye. F., Solov'yeva, O. N., and Lazareva, A. P. Rayleigh wave dispersion and crustal structure in northern Eurasia and in the Atlantic Ocean. See Geophys. Abs. 184-430.

Nishimura, Eiichi; Kamitsuki, Akira; and Kishimoto, Yoshimichi. Some problems on Poisson's ratio in the earth's crust. See Geophys. Abs. 184-434.

ELASTICITY

184-215. Haskell, Norman A. Crustal reflection of plane SH waves: Jour. Geophys. Research, v. 65, no. 12, p. 4147-4150, 1960.

An equation has been derived for the amplitude of the free surface displacement due to plane SH waves incident at any angle at the base of a layered crust. Numerical computations have been carried through for the case of a single-layered model of the continental crust. At any given angle of incidence the surface amplitude goes through a series of minimums and maximums at periods which, in the single layered case, are harmonically related. At nearly grazing angles of incidence the surface amplitude is relatively small except at periods in the neighborhood of the cutoff periods of the second- and higher-order Love-wave modes. The results throw some doubt on the "whispering gallery" effect as an explanation of the mode of propagation of long-period (20 to 30 sec) S-waves at S_n velocity. Applied to the case of an alluvial layer over a hard-rock basement, the theory appears to give an adequate explanation of the abnormally large amplitudes that occur on unconsolidated formations in the epicentral region of earthquakes. — Author's abstract

184-216. Dix, C. H[ewitt]. The reflected seismic pulse: Jour. Geophys. Research, v. 66, no. 1, p. 227-233, 1961.

Cagniard's theory is recast in a form that simplifies the approximate numerical calculation of the shape of the reflected pulse. A new set of potentials is introduced from which the displacement components can be calculated by differentiations that are easier to perform than those with the usual scalar and vector potentials. Four potentials are used, two for the vertical and two for the horizontal components of displacement. The irrotational and rotational vertical-displacement components are found by differentiation of the potentials with respect to time; the horizontal-displacement contributions are derived by a single horizontal differentiation. For the rotational parts the number of differentiations is reduced from two to one. The time differentiation is much easier to carry out than the space differentiations for the forms used in this paper. A numerical example, selected to throw light on the problem of securing reflections from the M-discontinuity, is worked out. The variation of shape and strength of the reflection with time and distance from source to receiver is studied in this example. — D. B. V.

- 184-217. Dix, C. H[ewitt]. Elastic pulse reflection—evaluation of some determinants: *Jour. Geophys. Research*, v. 66, no. 1, p. 235-236, 1961.

The fourth-order determinants that occur in the theory of reflection are split into a sum (denominator) and difference (numerator) of two much simpler determinants. This makes the algebra much simpler. It also makes the form similar to that familiar for normal incidence. — Author's abstract

- 184-218. Peet, W. E. A shock wave theory for the generation of the seismic signal around a spherical shot hole: *Geophys. Prosp.*, v. 8, no. 4, p. 509-533, 1960.

The shape of the seismic signal generated by an explosive charge is assumed to be governed by shock-wave phenomena in a nonlinear region around the shot hole. The dimensions of this shock-wave region are shown to depend on the weight of the charge and the properties of the medium in which the shot is fired. For an ideally elastic medium the amplitude of the pulse outside the nonlinear zone is found to vary as the $1/3$ power of the charge weight. If the medium and (or) seismic instrument attenuate the high frequencies more than the low, a power law of the type $A=cQ^n$ (where A =amplitude, Q =charge weight, c =a constant) can be expected in which $n=1/3$. The exponent n is a function of charge weight and theoretically can reach a maximum value of $4/3$ for very small charges; for large charges, however, values nearer to $1/3$ are to be expected. — D. B. V.

- 184-219. de Hoop, A. T. A modification of Cagniard's methods for solving seismic pulse problems: *Appl. Sci. Research*, sec. B, v. 8, no. 4, p. 349-356, 1960.

A modification of Cagniard's method for solving seismic pulse problems is given. In order to give a clear picture of our method, two simple problems are solved, namely, the determination of the scalar cylindrical wave generated by an impulsive line source and the scalar spherical wave generated by an impulsive point source. — Author's summary

- 184-220. Craggs, J. W. On two-dimensional waves in an elastic half-space: *Cambridge Philos. Soc. Proc.*, v. 56, pt. 3, p. 269-285, 1960.

Two-dimensional elastic waves in a half space $0 < r < \infty$, $0 < \theta < \pi$ are examined under the assumption of dynamic similarity, so that the stresses depend only on r/t , θ . Analytic solutions are given for constant surface traction on $\theta=0$, $0 < r/t < V$, where V is constant, the rest of the surface being unloaded, and for a concentrated load at $r=0$. Numerical results are quoted for the particular case $V \rightarrow \infty$ corresponding to a load on half the bounding plane. — Author's abstract

- 184-221. Musgrave, M. J. P. Reflexion and refraction of plane elastic waves at a plane boundary between aeolotropic media: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 4, p. 406-418, 1960.

General equations in stress and displacement are set down and their implications qualitatively discussed. Detailed results are presented for the slownesses, amplitudes, and energy fluxes of body waves generated by the incidence of a body wave upon a range of differently oriented boundaries in hexagonal media. Results for ice and beryl show that assumption of isotropy preserves the qualitative form of the reflection characteristics; in contrast, the variations caused by changing the orientation of the boundary in zinc are too great to be adequately represented in terms of isotropic constants.

The problem was undertaken in order to investigate the effects of anisotropy in a simple reflection problem. Deviations from results obtained on the assumption of isotropy are of interest and could be of significance to seismologists and users of ultrasonic methods. — D. B. V.

- 184-222. Bolt, B[ruce] A., and Butcher, J. C. Rayleigh wave dispersion for a single layer on an elastic half space: *Australian Jour. Physics*, v. 13, no. 3, p. 490-504, 1960.

Numerical solutions of the period equation for Rayleigh waves in the single surface layer were calculated using the SILLIAC computer at the University of Sydney. Values of the phase and group velocities for both the fundamental and first higher mode are tabulated against period for 11 two-layer models. The related models allow a sensitivity analysis of the effect of variation in the seismic parameters. Values of the elastic constants used in the calculations were chosen to fit the seismic velocities determined for the crust in Western Australia, so that the solutions are relevant to studies of the crustal structure of Australia. — D. B. V.

- 184-223. Fredericks, R. W., and Knopoff, L[eon]. The reflection of Rayleigh waves by a high impedance obstacle on a half-space: *Geophysics*, v. 25, no. 6, p. 1195-1202, 1960.

The reflection of a time-harmonic Rayleigh wave by a high impedance obstacle in shearless contact with an elastic half-space of lower impedance is examined theoretically. The potentials are found by a function-theoretic solution to dual integral equations. From these potentials, a "reflection coefficient" is defined for the surface vertical displacement in the Rayleigh wave. Results show that the reflected wave is $\pi/2$ radians out of phase with the incident wave for arbitrary Poisson's ratio. The modulus of the "reflection coefficient" depends upon Poisson's ratio, and is evaluated as $r_R = 0.265$ for $\sigma = 0.25$. — Authors' abstract

- 184-224. Nagumo, Shozaburo; Kawashima, Takeshi; and Honsho, Shizumitsu. Model experiment on Rayleigh wave [in Japanese with English abstract]: *Butsuri-Tanko*, v. 12, no. 3, p. 129-133, 1959.

The propagation of a Rayleigh wave in a semi-infinite elastic medium was studied in a two-dimensional model. It was found that the wave length of a Rayleigh wave on the surface becomes longer with an increase in the shot depth; the wave length is approximately twice the shot depth. The underground propagation of a Rayleigh wave is illustrated; the wave front of maximum amplitude seems to be inclined to the surface. The reciprocity of the Rayleigh wave between source and detector is ascertained within the error of the experiment. — V. S. N.

- 184-225. Takeuchi, Hitoshi, and Kobayashi, Naoto. Surface waves propagating along a free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 2) [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 1, p. 1-8, 1960.

The variational calculus method used in part 1 (see *Geophys. Abs.* 181-134) is applied to the study of Love waves propagating along a free surface of a semi-infinite elastic medium, in which the density and elasticities change exponentially with depth. The method is also applied to the study of Love and Rayleigh waves in a uniform superficial layer upon a uniform semi-infinite medium. A trial function is shown that is useful in the study of Love waves in the case where the substratum is perfectly rigid. — V. S. N.

- 184-226. Donato, R. J. Experimental investigation on the properties of Stoneley waves: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 441-443, 1960.

This note describes measurements made both on the velocity and on the attenuation of the Stoneley wave and compares the results with theoretically predicted values. A barium titanate transducer placed on a paraffin wax block immersed in water excited the Stoneley wave. A similar transducer, whose height above the wax block could be varied, received the wave. The received signal was displayed on an oscilloscope together with a time "ruler" marked at 10μ sec and 100μ sec intervals. Oscillograms that show the different times of arrival of the Stoneley wave when the block is covered with water, and the Rayleigh wave when the block has a free surface and both the transducers rest on its surface, are reproduced. Time-distance curves were plotted for the dilatational and Stoneley waves for the block immersed in water; the velocities determined from this information are 21.3×10^4 cm per sec and 6.5×10^4 cm per sec, respectively. The Rayleigh wave velocities, determined similarly for the block in air, are 8.3×10^4 cm per sec. The dilatational and Rayleigh wave velocities are sufficient to specify the elastic constants of the paraffin wax, and with the added values of the velocity of sound in water and the densities of paraffin wax and water the Stoneley wave velocity can be calculated. The value found in this way is 6.8×10^4 cm per sec. — D. B. V.

- 184-227. Birch, Francis. The velocity of compressional waves in rocks to 10 kilobars, Part 1: Jour. Geophys. Research, v. 65, no. 4, p. 1083-1102, 1960.

The velocity of compressional waves has been determined by measurement of traveltime of pulses in specimens of rock at pressures to 10 kilobars and room temperature. Most of the samples, mainly igneous and metamorphic rocks, furnished three specimens oriented at right angles to one another. The present paper gives experimental details, modal analyses, and numerical tables of velocity as function of direction of propagation, initial density, and pressure. Discussion of various aspects of the measurements is reserved for part 2. — Author's abstract

- 184-228. Auburger, Michel, and Rinehart, John S. Energy loss associated with impact of steel spheres on rocks: Jour. Geophys. Research, v. 65, no. 12, p. 4157-4164, 1960.

The coefficient for restitution for impact between steel spheres and plexiglas, and between steel spheres and nine different rocks has been measured: granite, sandstone, limestone, and six marbles. The energy loss associated with the impact has been studied as a function of the sphere diameter, particularly for three diameters: $1/8$ in., $1/32$ in., and $1/64$ in. Such a study permits a correlation with attenuation of shear wave as a function of frequency in the frequency range of 30 to 240 kc per sec. Attenuation has been found to be strongly dependent on the main constituents of the rocks, their grain size, and the nature and size of their intergranular particles. Attenuation increases with the number of grain boundaries per unit volume and is lowered when the intergranular cement is made up of grains a few microns thick. Shear attenuation is several times larger than longitudinal attenuation in most of the rocks tested. — Authors' abstract

- 184-229. Auburger, Michel, and Rinehart, John S. Ultrasonic velocity and attenuation of longitudinal waves in rocks: Jour. Geophys. Research, v. 66, no. 1, p. 191-199, 1961.

Hughes' pulse technique for measuring longitudinal velocities has been adapted and extended to measure attenuation of longitudinal waves in the frequency range from 250 to 1,000 kc. Data for velocity and attenuation in 8 different rocks (3 granite, 1 porphyry, 2 sandstones, 1 limestone, and 1 marble) are given at eight different frequencies ranging from 250 to 1,000 kc. The values of attenuation measured have been found to be much higher than for metals and plastics in the same frequency range. They lie between 1 and 37 decibels per centimeter. All of the curves of attenuation versus frequency show one or several peaks, none of the curves indicating a marked law of increase or decrease of attenuation with frequency. In one granite, in the limestone, and in the marble successive peaks occur at harmonic frequencies. A comparison between the wavelengths for which the peaks occur and the grain size of the rocks shows a good agreement for the coarse-grained rocks between the frequencies of occurrence of the peaks and the resonance frequencies of the largest crystals of the rocks, indicating a very large effect of the frictional boundary losses on attenuation when the wavelength approaches the grain size of the rock. — Authors' abstract

- 184-230. Peselnick, Louis, and Outerbridge, W. F. Internal friction in shear and shear modulus of Solenhofen limestone over a frequency range of 10^7 cycles per second: *Jour. Geophys. Research*, v. 66, no. 2, p. 581-588, 1961.

The internal friction in shear and modulus of rigidity of dry Solenhofen limestone was investigated over a frequency range from 4 cycles per second to 10 megacycles per second at room temperature. It was found that the rigidity modulus is constant ($U = 2.64 \times 10^{11}$ d per cm^2) to within ± 2 percent over the total frequency range covered, if the samples have the same density; that the shear internal friction in the cycle-per-second frequency range is about a factor of 5 lower than the internal friction in the megacycle frequency range; that the logarithmic decrement at 4 cycles per second is 3.4×10^{-3} and at 10^7 cycles per second is 17×10^{-3} ; that the shear internal friction in the infrasonic frequency range increases by 18 percent with the application of a 7.2-kg per cm^2 static axial tensile stress, but no large change in the internal friction occurs for axial compressive stress of the same magnitude; and that the shear internal friction is strain-dependent even for strains as small as 10^{-6} , a static axial tensile stress being superposed on the dynamic torsional stress. — D. B. V.

- 184-231. Knopoff, L[eon], and Gangi, A[nthony] F. Transmission and reflection of Rayleigh waves by wedges: *Geophysics*, v. 25, no. 6, p. 1203-1214, 1960.

Experimental observations have been made of the transmission and reflection of Rayleigh waves by wedges. Results are reported for Rayleigh waves in aluminum wedges. It is observed that the wave shapes of the transmitted and reflected waves differ from that of the incident wave and depend on the angle of the wedge. The change of shape is attributed to an interference between part of the incident wave-form and the radiation from a line source placed at the vertex. A procedure is given for the calculation of the partition between the two terms. — Authors' abstract

- 184-232. Viksne, Andris, Berg, Joseph W., Jr., and Cook, Kenneth L. Effect of porosity, grain contacts, and cement on compressional wave velocity through synthetic sandstones: *Geophysics*, v. 26, no. 1, p. 77-84, 1961.

Compressional wave velocities through 36 synthetic sandstone cores were measured and related to porosity, manufacturing pressure, grain contacts,

and amount of cement. The results are presented graphically. For cement contents between 10.0 and 17.5 percent, the velocity is directly controlled by manufacturing pressure and porosity; it is also dependent to a great extent on the number of grain contacts, which is intimately associated with manufacturing pressure, and the cement content, which is intimately associated with porosity. For cement contents greater than 17.5 percent by volume, the sand grains float in the cement, and the analogy with natural sandstones is questionable. — D. B. V.

- 184-233. Donato, R. J. Seismic model experiments on the shape and amplitude of the refracted wave: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 270-271, 1960.

The experimental verification by means of seismic model techniques of both the wave shape and the amplitude predicted by theoretical considerations is described. Liquid mediums were used; an electric spark immersed in the medium overlying the refractor simulated the seismic explosive source, and a lead zirconate transducer separated horizontally from the source by a distance R received the refracted wave. Photographic records of the original pulse, the pulse after passing through an electronic integrator, the refracted pulse, and the numerical integration of the original pulse are reproduced. — D. B. V.

- 184-234. Starodubrovskaya, S. P. Eksperimental'noye izucheniye osobennostey prodol'nykh voln, otrazhennykh ot tonkogo sloya [Experimental study of features of longitudinal waves reflected from a thin layer]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1466-1473, 1960.

On the basis of experimental data obtained for various depths for a thin layer with $h/\lambda_2=0.15$, $h/\lambda_1=0.3$, and $v_1/v_2=0.5$, the following conclusions were drawn. A wave reflected from a thin layer in both areas of investigation can be correlated clearly on the record. The dynamic properties of a wave—form of the record, amplitude, and frequency—do not change with distance from the source. Waves registered for various depths of the thin layer are characterized by different predominating frequencies and different attenuations of amplitude with distance. — J. W. C.

- 184-235. Panel on Seismic Improvement. The need for fundamental research in seismology: U.S. Dept. State Rept. of Panel on Seismic Improvement, 214 p., 1959.

A detailed report is presented on the need for fundamental research in seismology; it is the result of studies by a panel appointed to review the feasibility of improving the Geneva control system for detecting and identifying underground events. The first part summarizes the general need for seismic research, source phenomena, propagation of seismic waves, detection, data processing, and the administration and budget for a new level of seismological research. The second part includes twenty-one papers which are the subject of the following abstracts (184-236 through 184-256). — V. S. N.

- 184-236. Press, Frank, and Griggs, David T. Improved equipment for existing seismic stations: U.S. Dept. State Rept. of Panel on Seismic Improvement, app. 1, p. 17-18, 1959.

It is proposed that the 100-200 best seismograph stations in the world be equipped with modern instruments for the accumulation of valuable data which would be used in research programs for distinguishing earthquakes from ex-

plosions. Improvement in the United States seismic capability should be the first step with equipment to be selected by a panel of American seismologists and with the possible establishment of new stations. — V. S. N.

- 184-237. Romney, Carl. Short period shear waves and their application to discriminating between earthquakes and explosions: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 2, p. 19-21, 1959.

Four approaches are presented for developing suitable criteria for using the shear waves to discriminate between earthquakes and explosions: existence of SH, azimuthal variations of SH/SV ratio, absence of SN in some nuclear explosions, and the ratio of S/P. Six type questions are presented to be answered by a possible experimental program, and recommendations are made for the conduct of the program with an estimate of costs and time schedules. — V. S. N.

- 184-238. Gerrard, John. Unattended auxiliary seismic stations: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 3, p. 22-41, 1959.

Simplified, unattended auxiliary seismic units within the network of manned stations specified at the Geneva Conference are recommended for use to insure a sufficient signal-to-noise ratio at the manned control posts and to obtain comprehensive information on first-motion patterns caused by an event. The seismic stations will be arrayed to receive the incoming wave train associated with the P-wave. — V. S. N.

- 184-239. Press, Frank. Aftershocks as a means of identification of earthquakes: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 4, p. 42, 1959.

A statistical study, limited to earthquakes of magnitude 4-5 and aftershocks that occurred within one week after the initial tremor, was made of aftershocks with a view toward using their presence or absence as a means of identifying earthquakes. It was concluded that aftershocks could be of some use. The capability of the method depends upon how quickly temporary stations can be installed near the epicenter of a suspicious event; for southern California the capability is 50 percent. — V. S. N.

- 184-240. Press, Frank. Long period surface and body waves: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 5, p. 43-45, 1959.

It is believed that earthquakes are more efficient in the generation of lower frequency body waves and surface waves than are explosions of equivalent magnitude. Preliminary studies reveal differences in spectra of body waves and surface waves; therefore, these differences are a possible method of distinguishing explosions from earthquakes. An extensive research program is recommended that would emphasize statistical studies of spectra, Love/Rayleigh energy distribution, and SV/SH ratios of earthquakes, quarry blasts, and underground nuclear explosions. Also phase and group velocities of surface waves and their variations across continents would be studied with special tripartite arrays of long-period seismographs. — V. S. N.

- 184-241. Knopoff, Leon. Deductive seismology: U. S. Dept. State Rept. of Panel on Seismic Improvements, app. 6, p. 46-51, 1959.

Observational seismology is concerned with the inductive problem and should be evaluated in terms of some probability or other weighting factor that describes the likelihood of the solution being correct. The deductive problem, on the other hand, is a problem in mathematical analysis and is exact. If the problem to be solved is appropriately described, then a specification of the nature of the structure, the source, and the receiver must be made. Problems to be solved are assumed to be problems in linear mechanics so that linear transform procedures are permissible. Problems of linear wave motions in solids to be considered are those of physical theory which determine the character of the wave motions following the arrivals. Methods are discussed for obtaining solutions for the elementary geometries such as half-spaces, layered media, wedges, half-plane diffraction problems, imbedded spheres, imbedded circular cylinders, imbedded wedges, imbedded cylinders of irregular shape, the influence of irregularities in smooth simple surfaces, and others. Construction of a seismogram for more complex geometries is an exercise that may require extensive data processing and computational and data handling facilities of some size. — V. S. N.

- 184-242. Street, Kenneth. Need for high explosive and nuclear tests for research program: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 7, p. 52-57, 1959.

To date no exclusive phenomena have been found that are characteristic only of the seismic phenomena produced by a nuclear explosion. It is imperative that the parameters that can conceivably affect to a significant extent the magnitude and type of seismic effects produced by a nuclear explosion be explored in a thorough manner so that these effects can be compared with those produced by natural earthquakes. It is necessary to investigate either theoretically or experimentally the effect of the following parameters on the body and surface waves proposed for use in discrimination: dependence of the waves on yield of the explosion, effect of the medium in which shot is fired, depth of burial, local environment, and large-scale geologic environment. As experimental program for use of nuclear and HE explosions to explore a number of parameters is outlined. — V. S. N.

- 184-243. Oliver, Jack [E.]. Seismic waves in the intermediate period range: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 8, p. 58-59, 1959.

Body waves, surface waves, and microseisms in the intermediate period range from 1 to 20 or more seconds but generally in the 4 to 12 second range are discussed as important areas for emphasis in a research program. Good instrumentation is needed for these studies and in the case of body waves a large network of uniform instrumentation is important. — V. S. N.

- 184-244. Tukey, John W. Equalization and pulse shaping techniques applied to the determination of initial sense of Rayleigh waves: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 9, p. 60-129, 1959.

An empirical method or so-called "black-box" method is described that determines the effect of the propagating medium and the seismograph on the recorded wave train, and then applies this effect inversely to similar trains in order to infer the sense of the pulse, that is, the nature of the disturbance near the source. The method is best applied to long-period surface waves. Some details of the method and its implementation are discussed in Annexes A through E as follows: phase compensation, numerical techniques, synthesis of digital phase compensators, details of analysis, and possibilities of implementation in practice. — V. S. N.

- 184-245. Oliver, Jack [E.]. The phase compensation method of equalization: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 9a, p. 130-131, 1959.

A method of equalization based upon well-understood properties of the earth rather than upon the empirical behavior of waves from another earthquake is presented. Once phase velocities have been determined over an entire continent or over the world, phase compensation can be based upon known properties. The method of determining phase velocities and a simplified method of seismogram-analysis which permits the effects of these mechanisms to be subtracted from the recorded seismic wave train and thus determination of the nature of the sense or seismic pulse near the source are described. The method requires a network of stations so that individual phases of the seismic wave train may be traced across a given interval. Results of preliminary measurements in the United States demonstrate that such a study is feasible with a network of stations such as that proposed by the Geneva Conference. — V. S. N.

- 184-246. Press, Frank, and Griggs, David T. Geophysical investigation of continental crustal structure: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 10, p. 132-133, 1959.

A program is proposed for the investigation of crustal structure along several profiles, each 400 km long starting in the vicinity of the Sierra Nevada, the Great Basin, and the Rocky Mountains. Twelve-channel oscillographic and magnetic tape recording apparatus with groups of 4 seismometers per channel with each group spaced at intervals of 1,000 feet will be used. Overall channel response will extend down to 2 cycles per second with variable high and low frequency cutoff. Explosions will be loaded and detonated by the contractor and continuous radio contact will be maintained between shot point and recording position. It is also proposed to establish a network of long period seismograph stations to analyze the data for phase and group velocity of surface waves and to use Fourier transform methods to recover the shape of the initial impulse. Explosive and earthquake sources will be used and modern computing machine methods of data reduction and analysis will be exploited. This work will be performed jointly with the explosion studies. Explosion methods reveal fine details of crustal structure variation, whereas the surface wave method reveals the regional picture. — V. S. N.

- 184-247. Oliver, Jack [E.]. Ocean bottom seismographs: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 11, p. 134-136, 1959.

Determination of the seismic motion of the floor of the ocean is one of the more significant areas of experimentation open to the seismologist. Ocean bottom seismographs could obtain information on seismic noise level; on body waves; on surface waves, particularly the nature of the 5-15 second waves propagating across oceanic paths and the lack of short-period waves of the fundamental Rayleigh mode; on the near-surface wave guide of the oceanic crust; on microseisms; and on low frequency sound propagation. Seismometers connected to the shore by cable, or by telemetering data acoustically to a ship, or with the entire seismograph on the bottom could be used. — V. S. N.

- 184-248. Benioff, Hugo. Suggestions for standards of noise, amplitude, and spectrum: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 12, p. 137-138, 1959.

Seismic noise exhibits a continuous spectrum with superposed bright lines or bands corresponding to microseism frequencies. Both the continuous spectrum

and the microseism bands vary in amplitude and frequency with time and from place to place. The seismic amplitude spectrum should be measured with appropriate frequency resolution over a frequency range from about 20 millicycles per second to 10 cycles per second at several sites and for 3 components. Determinations of average spectrum levels for minimum, average, and maximum noise conditions should be made for each site, and measurement of other noise characteristics, such as spatial coherence and type of distribution, are desirable. To obtain the ratio of signal to noise, measurements of the amplitude spectrums in 3 components of the initial P-waves and surface waves of earthquakes and underground blasts at different distances from the source and at different observing sites are necessary. — V. S. N.

- 184-249. Benioff, Hugo. Improved seismographs: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 13, p. 139-144, 1959.

Suggested improvements for short period seismographs and for surface wave seismographs for improved detection and identification of earthquake and blast waves are discussed. Development of such seismographs must be coordinated with information on the spectrums of signals and noise not now available. — V. S. N.

- 184-250. Gerrard, John. "Throw-away" or portable seismic probes for operation on land: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 14, p. 145-151, 1959.

Simple "throw-away" or portable seismic units, which can be placed immediately and in quantity over a suspicious area, afford an effective means of supplying valuable information concerning aftershocks to the fixed seismic network. These units may furnish relatively detailed information on first-break patterns in any region where seismic activity is high. Analog data transmission and visual monitoring of results will be adequate. These probes could be placed on the ground manually or dropped from the air and would be particularly useful in detecting the nature of a shock in regions where aftershock activity is high. The following factors which might affect the feasibility of obtaining useful data from the units are discussed: environmental factors affecting seismic unit performance at the site, optimum placement and monitoring of units, and data interpretation. The seismic equipment to be employed and the method of data processing within the unit are also discussed. — V. S. N.

- 184-251. Gerrard, John. Use of multiple arrays in seismic detection: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 15, p. 152-163, 1959.

An increase in the effective signal-to-noise ratio can be realized by sampling the ground motion over a fixed area with an increased number of seismometers placed in a suitable array pattern. Enhancement for a given increase in number of sampling sites for a given incoming wave will depend upon the selection of the site pattern, the manner in which data recombines, and the numerical operations performed on the raw and combined data. These factors will vary from shock to shock and from station to station. The selection of array patterns will be dependent upon the digital computer capabilities. — V. S. N.

- 184-252. Gerrard, John. Data-processing requirements: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 16, p. 164-183, 1959.

This report discusses anticipated problems, possible procedures, and areas in which study and development will be required in establishing an advanced data-processing system to accompany the suggested Geneva seismic network.

Speedy performance of calculations will require automatic data-processing equipment, and special-purpose machines optimized for this task should be designed. A technical program is suggested and a preliminary estimate of cost and personnel presented. — V. S. N.

- 184-253. Gerrard, John. Program to establish a complete experimental seismic station for the evaluation of network instruments and methods: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 17, p. 184-185, 1959.

A complete, experimental seismic station is suggested as a single major unit in the expanded Geneva network. The station would provide a facility for field evaluation of the instrumentation and methods suggested by the proposed research program. Some of the problems to be worked out at this experimental station are itemized, and phases for the establishment of the station are listed. — V. S. N.

- 184-254. Romney, Carl. Deep hole detection techniques: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 18, p. 186-192, 1959.

Theoretical reasoning and some experimental work suggest that seismographs installed and operated at depths of several thousand feet below the surface may detect smaller P-wave signals than those at the surface. This is suggested by the belief that surface noises die off rapidly with depth. A long-term research program now in progress and problems for future study are discussed. — V. S. N.

- 184-255. Gerrard, John. Research computing facilities and a digital library of seismograms: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 19, p. 193-194, 1959.

The establishment of a computing center to assist in study and analysis of seismic records is proposed. Facilities which should be available at the center are listed and a preliminary budget is presented. — V. S. N.

- 184-256. Gerrard, John. Considerations on the standardization of seismometers to be used in the Geneva network: U. S. Dept. State Rept. of Panel on Seismic Improvement, app. 20, p. 195-214, 1959.

Standardization and calibration of the various seismic instruments constituting the stations of the Geneva network appears to be feasible. Calibration and limited standardization of seismometer ground "plant" appear to require considerable experimental evaluation and study. A technical program is outlined and an estimate of cost and personnel is presented. — V. S. N.

- 184-257. Griggs, David T., and Press, Frank. Probing the earth with nuclear explosions: Jour. Geophys. Research, v. 66, no. 1, p. 237-258, 1961; also in Univ. California Radiation Lab. Pub. UCRL 6013, 40 p., 1960.

Progress in seismology is reviewed with emphasis on the usefulness of past nuclear weapon tests in determining the internal structure of the earth. Shot times and locations are tabulated for 169 U. S. atomic explosions, with seismic data from Pasadena. The advantages of using large chemical explosions and future nuclear explosions detonated under the Plowshare program as controlled energy sources for carefully instrumented seismological experiments are discussed. Finally, an international program of explosions for seismological research is proposed, and specific suggestions are made for attacking

several outstanding problems in seismology by means of chemical and clean nuclear explosions and the instrumentation network proposed at Geneva for nuclear test detection. Deep oceanic seismometer lines are proposed as a means for making important improvements in seismic knowledge of the world and possible improvements in the detection of atomic explosions. — Authors' abstract

- 184-258. Adams, [William] M[ansfield], Preston, R. G., Flanders, P. L., Sachs, D. C., and Perret, W. R. Summary report of strong-motion measurements, underground nuclear detonations: Jour. Geophys. Research, v. 66, no. 3, p. 903-942, 1961.

This is the same as the paper published in U.S. Atomic Energy Comm. [Pub.] ITR-1711, 80 p., 1960 (see Geophys. Abs. 182-175). — D. B. V.

- 184-259. Latter, A[lbert] L., LeLevier, R. E., Martinelli, E. A., and McMillan, W. G. A method of concealing underground nuclear explosions: Jour. Geophys. Research, v. 66, no. 3, p. 943-946, 1961.

It is shown theoretically that the seismic signal from an underground nuclear explosion can be greatly reduced by carrying out the explosion in a large cavity. An estimate of the effectiveness of the method indicates that a yield of more than 300 kilotons (HE-equivalent) could be made to look seismically like a yield of 1 kiloton. Experiments with both chemical and nuclear explosions are needed to test the theory. — Authors' abstract

- 184-260. Murphey, Byron F. Particle motions near explosions in halite: Jour. Geophys. Research, v. 66, no. 3, p. 947-958, 1961.

Peak particle velocities and displacements were measured for tamped (coupled) and cavity (decoupled) explosions in halite. Recordings are illustrated of particle velocity versus time in the salt medium and of pressure versus time on the cavity wall. Peak particle velocities from tamped shots decrease as $d^{-1.65}$ over distances equivalent to 40 to 800 feet for 1,000 pounds of high explosive. Decoupling factors that were directly observed apply only to close-in stations. One method of extrapolating close-in data yields distant decoupling factors ranging from 40 to 100 for these particular experiments. Actual measurements (verbal communication from Herbst, 1960) of distant decoupling factors give larger numbers by a factor of 2. Extrapolation to nuclear explosions is not attempted here. — Author's abstract

- 184-261. Herbst, Roland F., Werth, Glenn C., and Springer, Donald L. Use of large cavities to reduce seismic waves from underground explosions: Jour. Geophys. Research, v. 66, no. 3, p. 959-978, 1961.

The results of "Project Cowboy," an experiment designed to test the theory of seismic decoupling of underground explosions proposed by Latter and others (see Geophys. Abs. 184-259), are analyzed. A series of 8 high-explosive shots were made in two spheres excavated in a salt dome, and 9 tamped shots were made for comparison. A salt-to-salt decoupling factor of 100 was obtained, which is consistent with the predicted tuff-to-salt factor of 300. The experiment verifies the prediction that seismic signals from cavities that yield elastically will be very small compared with the signal from fully tamped shots. The surface measurements and the close-in measurements are consistent with one another and with the decoupling theory. The results show further that an explosion in a sphere smaller than that necessary to insure elasticity will still decouple. — D. B. V.

- 184-262. Lamb, George L., Jr. Some seismic effects of underground explosions in cavities: Univ. California, Los Alamos Sci. Lab. Rept. La 2405, 65 p., 1960.

A number of the effects created by a seismic explosion contained within an underground cavity of a size sufficient to ensure elastic behavior of the side walls are investigated theoretically. The Rayleigh waves generated by a source of compressional waves in a semi-infinite homogeneous elastic medium are calculated; the stress concentration around a spherical cavity in a homogeneous elastic medium acted on by an arbitrary body force is determined and the results specialized to the case of a uniform gravitational field with vanishing lateral displacement; the stress distribution around a prolate spheroidal cavity in a uniform gravitational field with vanishing lateral displacement is considered, and the plastic expansion of a spherical cavity in an infinite elastic medium is discussed. A final chapter discusses seismic waves generated by an air burst. — V. S. N.

- 184-263. Johnson, Gerald W. Application of nuclear explosions as seismic sources: Univ. California Radiation Lab. Pub., UCRL 6030-T, 51 p., 1960.

The information of interest to earth science obtained from detonation of nuclear and large chemical explosions is briefly reviewed. The major geophysical questions as suggested by Griggs and Press (see Geophys. Abs. 184-257) that might be resolved under a program of earth structure research involving both nuclear and chemical explosions are given.

Underground nuclear explosions in the United States and their interpretation with a description of methods of stemming the explosion to assure containment of radioactivity are summarized. An estimate of typical costs that might be incurred in the United States to provide seismic sources is presented. It is concluded that nuclear explosions can be economical and safe seismic sources; chemical explosives can be used for low energies, but at about a kiloton nuclear explosions become comparable in cost, and at a few thousand tons they are much cheaper. — V. S. N.

- 184-264. Weston, D. E. The low-frequency scaling laws and source levels for underground explosions and other disturbances: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 191-202, 1960.

A general approach is used to show that the source spectrum level for the energy radiated from a disturbance is usually proportional to (frequency)² at low frequencies, and also that this low-frequency energy is proportional to (total energy)² for body waves. There are differences for one- and two-dimensional propagation, and also for interface waves. Applied to underground explosions, the theory provides the best explanation of the empirical law that seismic amplitude is proportional to charge weight. The reason why underwater explosions have much more low-frequency energy than those underground (10 percent efficiency compared to 0.05 percent), making underwater explosions more suitable as sources for seismic investigations, is discussed.

The general method is applicable to a wide range of other mechanical disturbances and also to electromagnetic pulses. — D. B. V.

ELECTRICAL EXPLORATION

- 184-265. Vozoff, K[eeva]. Numerical resistivity interpretation: general inhomogeneity: Geophysics, v. 25, no. 6, p. 1184-1194, 1960.

A linear approximation is developed for the equation of conduction in a medium where resistivity is an arbitrary function of x , y , and z . This is applied by assuming the earth to be subdivided into small, homogeneous blocks of arbitrary resistivity. Under this approximation, the apparent resistivity is just the sum of the effects of the individual blocks. The equations are linear, and surface apparent resistivity data can be inverted to yield block resistivities. The quality of the approximation has been checked by comparison with model measurements in two situations: remote current source (telluric method), and local current source (resistivity method). It was found that the results are satisfactory provided that the proper type of expression is used for the effect of the resistivity contrast of each block. — Author's abstract

184-266. Brundage, Harrison T. New radio reflection method finds oil and gas directly: *World Oil*, v. 152, no. 4, p. 54-57, 1961.

Radio wave reflection techniques have been developed for direct determination of the presence or absence of oil, gas, or gas condensate deposits, and field tests have been successful. Radio energy loaded into the subsurface is evidently reflected by the hydrocarbon deposit because of the electrochemical difference between hydrocarbons and salt water. This electrochemical difference is more pronounced at the edges of a pool than at the center; hence the method may be used to particular advantage in outlining pools. The radio frequency transmitter, which emphasizes stability of both power output and frequency, is installed in a light house trailer. The receiver is mounted on a light semi-amphibious vehicle equipped with power supply. — J. W. C.

184-267. Seigel, H. O. A theory of induced polarization effects (for step-function excitation), in *Overvoltage research and geophysical applications*: *Internat. Ser. Mon. Earth Sci.*, v. 4, p. 4-21, 1959.

Overvoltage effects (induced polarization), including all polarization effects and considering a dynamic rather than a purely electrostatic model, are equivalent to a volume distribution of current dipolar sources, each dipole being antiparallel to the primary current density, j , at each point and with a volume current moment of strength $M = -mj$, where m is a constant which is called the "chargeability". If E is the impressed electrical field due to external sources, the total current density j due to both the external and dipole fields is $j = \sigma(1 - m)E$, where σ is the conductivity of the medium. If σ is the voltage at time of current interruption due solely to the impressed external field and σ' that due to the external plus the dipole fields, the ratio of the peak secondary voltage to the total voltage is $(\phi' - \phi)/\phi' = m$, the chargeability, in a homogeneous medium. This ratio is thus independent of electrode configuration or shape or size of the body and is a function solely of the chargeability, as was observed experimentally and in the field.

For a heterogeneous ground composed of a series of media of resistivities ρ_i and chargeabilities m_i , the apparent chargeability m_a of the ground is

$$m_a = \sum m_i \frac{\partial \log \rho_a}{\partial \log \rho_i} \leq \frac{\partial \log \rho_a}{\partial \log \rho_i}$$

where ρ_a is the apparent resistivity of the ground. In the case of a 2-layer medium this reduces to

$$\frac{m_a - m_1}{m_2 - m_1} = \frac{\partial \log \rho_a}{\partial \log \rho_2}$$

Examples are given of the form of the response curves for a spherical ore body for 2, 3, and 4 electrode arrays, and of the application of the method to 2 actual field cases in Colorado and Peru. — J. H. S.

- 184-268. Wait, J. R. A phenomenological theory of overvoltage for metallic particles, in *Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci.*, v. 4, p. 22-28, 1959.

A brief theoretical derivation is presented for the effective conductivity and dielectric constant of a homogeneous medium loaded with a uniform distribution of spherical conducting particles. To account for the effect of induced polarization, the particles are taken to have a concentric membrane or film which has a blocking action to the current flow into the particle. — Author's abstract

- 184-269. Wait, J. R. The variable-frequency method, in *Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci.*, v. 4, p. 29-49, 1959.

It has been found that the complex conductivity of rocks is a function of frequency. These dispersion or overvoltage effects, which are very pronounced in mineralized media, can be attributed mainly to interfacial polarization at the boundaries of the metallic ore particles and the electrolyte in the pores of the host rock. In the first part of this paper, the variation of the magnitude and the phase of the conductivity for mineralized and non-mineralized samples is reported for frequencies in the range from 0.1 to 10^5 cycles per second. The mathematical relation between a frequency dependent conductivity and the transient build up of the field for a step function current is then derived. The interrelation is demonstrated by an actual example which is verified experimentally for a mineralized sample. In the second part, electromagnetic propagation and interwire coupling effects are discussed briefly from the standpoint of their masking effect on the overvoltage measurement when a four electrode array is employed. In the third part, results from a preliminary field trial of the frequency variation method carried out in the summer of 1950 in the vicinity of Jerome, Ariz., are described. — Author's abstract

- 184-270. Collett, L. S., Brant, A. A., Bell, W. E., Ruddock, K. A., Seigel, H. O., and Wait, J. R. Laboratory investigation of overvoltage, in *Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci.*, v. 4, p. 50-69, 1959.

The technique used for the laboratory studies of induced polarization in mineralized and nonmineralized rock specimens is discussed. The equipment for both the transient and the frequency variation procedures is described in outline. Some typical results are presented for pyrite, chalcocite, copper, graphite, chalcopyrite, bornite, galena, magnetite, malachite, and hematite. — J. W. C.

- 184-271. Wait, J. R., and Collett, L. S. Criteria from the transient decay curves, in *Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci.*, v. 4, p. 71-83, 1959.

Induced polarization decay curves on rock specimens are analyzed; particular attention is given to the shape of the curves. For this purpose the first, second, and third derivatives are evaluated and shown plotted against the magnitude of the response in each case. The rates of decay in the 3-sec region and in the 1-sec region appear to be diagnostic of mineralization. Percentages of mineralization, however, are not easily estimated from the induced polarization curves. — J. W. C.

- 184-272. Ness, N. F. Analysis of the frequency response data; in Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci., v. 4, p. 84-91, 1959.

A study of the frequency spectrum of induced polarization was undertaken to determine whether this might aid in the recognition of metallic mineralization. The frequency spectrum was derived by Laplace transform theory from the impulse function obtained from the decay curve

$$g(t) = \sum_{i=0}^n A_i [1 - \exp(-a_i \tau)] \exp(-a_i t)$$

where $g(t)$ is the voltage difference between two step functions separated by a time interval τ , t is time since zero time, and A_i and a_i are constants. The time constants a_i are arbitrarily selected on the basis of previous experience, and the values A_i determined by minimizing the aggregate squared error. Four quantities may be determined: (1) in-phase component, (2) out-of-phase component, (3) phase angle, and (4) magnitude, only one of which is independent. Ness concludes that the out-of-phase component is best suited to the separation of possible effects. A total of 500 samples were available for analysis, but all could not be included. For practical reasons the frequencies used were restricted to 0.01-10.0 cycles per second. Within this frequency range the spectrum was well spread out, but there appeared to be no well-defined or characteristic differences in spectrum behavior that could be used to predict the presence of metallic particles. It is concluded that within this range no clear separation of mineralized-unmineralized responses is possible. — J. H. S.

- 184-273. Keller, G[eorge] V. Analysis of some electrical transient measurements on igneous, sedimentary, and metamorphic rocks, in Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci., v. 4, p. 92-111, 1959.

After reviewing the mathematical theory of induced polarization, the decay curves for a series of rock specimens of diverse types are evaluated. A comparison with theoretical curves and the graphic integration of the observed transients led to values of the time constant, T_0 ; the Wagner distribution constant, b ; the static capacity, E , for an infinite pulse; the resistivity, ρ ; and the product ρE . These are listed in a table for 103 specimens of sedimentary, igneous, and metamorphic rocks, and summarized by rock types and the average values of ρ and ρE in another table, which also includes 335 U.S. Geological Survey measurements. An inverse proportionality is noted between ρ and E so that the product ρE is relatively constant for a given rock type. It is concluded that induced polarization would be ideally suited for seeking disseminated ores in limestone, dolomite, or coarse-grained igneous rocks, but would be of little use for deposits of massive sulfides or for mineralized zones in sandstone. — J. H. S.

- 184-274. Ruddock, K. A. Field equipment for prospecting by the overvoltage method, in Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci., v. 4, p. 112-114, 1959.

Typical equipment for making transient overvoltage measurements is described and illustrated with block diagrams. — J. W. C.

- 184-275. Baldwin, R[obert] W. Overvoltage field results, in Overvoltage research and geophysical applications: Internat. Ser. Mon. Earth Sci., v. 4, p. 115-124, 1959.

The overvoltage or induced polarization method has been successful in delineating sulfide mineralization associated with porphyry coppers. Examples are shown from San Manuel, Ariz., and from Cuajone and other Peruvian prospects. Examples of response from other types of mineralization are given from Lynn Lake, Manitoba, and from South Africa. Mention is made of extraneous responses due to nonsulfides. — Author's abstract

- 184-276. Mayper, V., Jr. The normal effect—Part I, in *Overvoltage research and geophysical applications*: Internat. Ser. Mon. Earth Sci., v. 4, p. 125-141, 1959.

Various explanations of the normal effect are considered. Induced-polarization experiments are described, in which no normal effect whatever is obtained from "clean" artificial porous samples. Details of the experiments are given. The conclusion is drawn that, of the hypothesis so far advanced, the only ones still allowable are that the effect is due to a current-induced disequilibrium in the electrochemical properties of particles in the rock pores (probably ion exchange in clay), or that it is due to the presence of very slight true conductivity in some "nonconducting" minerals. Hypotheses involving electrokinetic effects, air bubbles, or surface conduction have been rejected. — Author's abstract

- 184-277. Mayper, V., Jr. The normal effect—Part II, in *Overvoltage research and geophysical applications*: Internat. Ser. Mon. Earth Sci., v. 4, p. 142-158, 1959.

It is concluded that the normal effect is caused by electrochemical phenomena within and on the surface of particles of clay and clay-like deteriorated mica in a rock. In addition, the presence of unrecognized conducting minerals has often caused effects indistinguishable from the normal effect. The anomalously high normals are ascribed to pore-structure effects in tight rocks, or to the presence of large amounts of unrecognized active material. These conclusions are arrived at principally on the basis of assays, petrographic analyses, porosity measurements, resistivity measurements, and critical experiments on a number of samples. The critical experiments consisted largely of measurements of induced-polarization response before and after the attempted elimination of clay by heating, by electrodialysis, and by crushing and removing the -2μ fraction. — Author's abstract

- 184-278. Malmqvist, David. Eine Analyse des zeitlichen Verlaufes von Polarisations-indikationen nach einer Gleichstrommethode [An analysis of the temporal course of polarization indications with a direct current method]: Freiburger Forschungshefte, C 81 Geophysik, p. 122-136, 1960.

The "S-method" of induced polarization, one that used direct current (originally proposed by Schlumberger in 1920), was tested in the Kankberg sulfide ore district in Sweden in 1958 with amazing results. A constant direct current was sent into the ground for 2-4 min, using the Wenner and Schlumberger configurations. Current intensity was 50-100 ma in one case, and 0.5-1.0 amp in another. The voltage between the two nonpolarizable potential electrodes was measured in the first second after closing of the circuit. After the current was cut off the voltage between the same electrodes was measured at given intervals (5, 15, 30, 60, 90, 120... sec). Both electrode arrangements gave clear anomalies over the orebody and over sulfide impregnations, corresponding well with their position as determined by electromagnetic measurements. Positive results have also been obtained with this method by Šumi

(see Geophys. Abs. 179-140) and by Komarov and Ryss (see Geophys. Abs. 177-117). The theoretical calculations and principles of the method are discussed at some length. — D. B. V.

- 184-279. Alfano, Luigi. The influence of surface formations on the apparent resistivity values in electrical prospecting. Pt. 1: Geophys. Prosp., v. 8, no. 4, p. 577-606, 1960.

The theory developed in a previous paper (see Geophys. Abs. 179-133) is applied to the problem of surface inhomogeneities with cylindrical structure. First, the case of measurements carried out with the potential electrodes near the irregularities and current electrodes farther from them is considered. A method is pointed out of separating the component of the electrical field due to deep formations from those due to surface irregularities.

Then the case of current electrodes near and potential electrodes more distant from the surface inhomogeneities is treated. For both cases numerical examples are given both for secondary values and for apparent resistivity values.

Finally, asymptotic values of vertical electrical soundings are calculated for some cases, showing rigorously that in the presence of surface disturbances these values are not generally equal to the true resistivity of a possible infinite substratum; therefore, resistivity measurement of an infinite substratum by means of the asymptotic resistivity value of only one sounding is not possible. — D. B. V.

- 184-280. Orellana Silva, Ernesto. Analogía entre los campos de corrientes y los electrostáticos aplicada a los métodos geoelectricos [Analogy between the electrokinetic and electrostatic fields applied to the geoelectric methods (with English abstract)]: Rev. Geofísica, v. 18, no. 69, p. 19-28, 1959.

The analogy that exists between the electrostatic and the electrokinetic fields is described and proved mathematically. Several examples of application of the analogy to elementary electrical prospecting are given, and it is shown that the analogy is valid only for prospecting using direct-current but not using alternating current. — V. S. N.

- 184-281. Korolenko, N. G., and Tsekov, G. D. Teoreticheskiye krivyye elektricheskogo zondirovaniya nad naklonnym kontaktom dvukh sred (paletki NK) [Theoretical curves of electric sounding over a sloping contact of two media (master charts NK)]: Prikladnaya geofizika, no. 24, p. 54-71, 1960.

Calculations of theoretical curves for electric sounding over a sloping contact of two media are described. An analysis is presented of the construction of master charts for an equatorial three-electrode set-up perpendicular to the strike of the contact for dips of $\alpha=5^\circ, 10^\circ, 20^\circ, 30^\circ, \text{ and } 45^\circ$, and for ratios of the two media corresponding to reflection coefficients $K=\pm 0.2, \pm 0.4, \pm 0.6, \pm 0.8, \pm 0.9, \text{ and } \pm 1.0$. — A. J. S.

- 184-282. Kaufman, A. A. Ob amplitudnykh i fazovykh kharakteristikakh poley, primenyayemykh v nizkochastotnoy elektrorazvedke [On amplitude and phase characteristics of fields used in low frequency electrical exploration]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 6, p. 87-91, 1960.

Phase frequency characteristics do not give information on the field that cannot be determined from the amplitude frequency characteristic. Therefore, in those methods where the amplitude values of the field are studied in a

wide range of frequency, it is not necessary to have apparatus for measuring phase. In some cases the phase frequency characteristic reflects features of the field more prominently than does the amplitude characteristic. Therefore, methods of calculation should be developed for eliminating this discrepancy. — J. W. C.

- 184-283. Kamenetskiy, F. M., and Kovalenko, V. F. Otsenka dlitel'nosti impul'sa pervichnogo polya pri возбуждении нестационарных вихревых токов с целью поисков хороших проводящих руд [Estimation of the length of the pulse of a primary field with excitation of nonstable eddy currents for the purpose of prospecting good conducting ore bodies]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 6, p. 92-94, 1960.

With a sufficiently long exciting impulse, the resolving capacity of the method of registration of the transient processes using periodic right-angle impulses shows practically no deterioration. The length of the exciting impulse should not be less than 50 m per sec. — J. W. C.

- 184-284. Zagarmistr, A. M., and Faradzhev, A. S. Ob ispol'zovanii trekh-elektrodney ustanovki s ekranirovannym elektrodom pri kartirovani ugol'nykh plastov vysokoy provodimosti [Application of a three-electrode apparatus with a shielded electrode in surveying and mapping coal seams of high conductivity]: Razvedka i Okhrana Nedr, no. 4, p. 35-38, 1960.

The effect of shielding the direct current used in electrical prospecting is discussed, and the apparent resistivity ρ_k is determined for a layer in the form of a curve represented by the $\Delta v/J$, Δv being the potential difference and J the current measured along the profile. A cross-check was made of field and model tests, the latter performed in a tank filled with a weak solution of copper sulfate and a copper sheet. The method can be used advantageously for finding location and dip of an ore body covered by several meters of alluvium. — A. J. S.

- 184-285. Svetov, B. S. Opyt primeneniya induktivnogo metoda razvedki [Experience in the use of the induction method of prospecting]: Razvedka i Okhrana Nedr, no. 7, p. 30-37, 1960.

Theoretical and model investigations demonstrated that the induction method increases the depth and effectiveness of prospecting for copper and polymetallic deposits as compared with other electrical methods. Using the frequency characteristics and amplitude-phase correlations of anomalous fields, conducting ore bodies can be distinguished according to their resistivities. The results of field tests designed to check the model investigations are reported. — A. J. S.

- 184-286. Gasanenko, L. B. Normal'noye pole vertikal'nogo garmonicheskogo nizkochastotnogo magnitnogo dipolya [Normal field of vertical harmonic low-frequency magnetic dipole]: Leningrad Univ. Uchenyye Zapiski, v. 249, no. 10, Voprosy Geofiziki, p. 15-36, 1958.

A numerical analysis of the electromagnetic field produced by a harmonic, low frequency, vertical magnetic dipole over a homogeneous half-space of finite conductivity is given, and the characteristic points (zero and extrema points) of the field are derived. It was found that the expression of the "electric number" of the vertical magnetic dipole corresponds to the expression of the vertical "magnetic number" of the horizontal electric dipole. Mathemat-

ical expressions for the components of the normal fields of vertical and horizontal magnetic dipoles are obtained and tabulated. — A. J. S.

- 184-287. Queille-LeFèvre, C[ollette], Bauer, [A.], and Girard. *Premier essai de mesure électrique d'épaisseur d'un glacier* [First attempt at electrical measurement of thickness of a glacier]: *Annales Géophysique*, v. 15, no. 4, p. 564-567, 1959.

The thickness of a glacier can be determined by electrical resistivity measurements. As an example, the thickness of the Saint-Sorlin glacier in the Alps was determined to be about 50 m and the resistivity of the ice to be 90 megaohm-m. The measurements confirmed the theoretical expectation that apparent resistivities would be strongly influenced by the presence of a surface layer of wet snow (see *Geophys. Abs.* 182-188). — D. B. V.

- 184-288. Fujino, Kazuo. An attempt to estimate the thickness of sea ice by electric resistivity method. I. [in Japanese with English résumé]: [Hokkaido Univ.] *Low Temperature Sci.*, ser. A, no. 19, p. 203-213, 1960.

The electric resistivity method was used to estimate the thickness of the sea ice on the Okhotsk Sea coast of Hokkaido. The system is treated as a simple three-layered structure (surface granular ice, mosaic ice, and sea water) as a first approximation. Results are given in a table. The coincidence of actual and analyzed values for total ice thickness is not good. Since analyzed values are generally larger than actual values, a "conversion factor" might be determined by statistical studies. — V. S. N.

- 184-289. Granar, Lars J. *Apparatur zur praktischen Ausführung elektromagnetischer Prospektierung auf tiefliegende Sulfiderze und ihre Aufwendung* [Apparatus for the practical execution of electromagnetic prospecting for deep-seated sulfide ores and its application]: *Freiberger Forschungshefte C 81 Geophysik*, p. 137-150, 1960.

This describes the compensator and absolute field measurement (AB-meter) techniques of electromagnetic surveying used in Sweden to detect sulfide ores as deep as 200-300 m. Measurements can be made up to a distance of 4 km on either side of a 10-km cable laid transverse to the general strike of the region. With either the compensator or the AB-meter, a 12-man party can carry out a reconnaissance survey of 40-50 km² in about 10 months using a single cable layout. The apparatus is described in detail with wiring diagrams and photographs, and illustrative examples of its use are given. The weak anomalies over deep orebodies amount to only a few percent of the normal field. With the compensator, the maximum relative measurement error is 0.5 percent, whereas with the AB-meter an accuracy of only 1 percent is attained part of the time. — D. B. V.

- 184-290. Aleva, G. J. J. *Geochemical and geophysical exploitation of the Nigadoo base metal deposit, N. B., Canada*: *Geologie en Mijnbouw*, v. 39, no. 10, p. 429-499, 1960.

The results of geochemical, self-potential, resistivity, and electromagnetic surveys of the Nigadoo sulfide ore deposit in New Brunswick are presented and discussed. The self-potential and resistivity surveys, together with the geochemical survey, gave information that led to drilling the first hole through sulfide. However, water-saturation of the ground made the results of these surveys unreliable in parts of the area. The Turam method gave much more

detailed information than the other methods, especially where the drainage conditions were undisturbed by mine workings. Because of its sensitivity and depth of penetration (to 500 feet), the Turam method is a reliable tool for eliminating unproductive ground. — D. B. V.

- 184-291. Hiersemann, Lothar. Untersuchung der hydrogeologischen Verhältnisse im Raum südlich von Greifswald durch geoelektrische Messungen [Investigation of the hydrogeologic relations in the area south of Greifswald by means of geoelectric measurements]: Geol. Gesell. Ber., v. 4, no. 2/3, p. 243-261, 1959.

Old resistivity surveys in the vicinity of Greifswald in East Germany are analyzed, and recent surveys are interpreted in order to determine the limitations and possibilities of the method in this area. It was found that the contact of a salt invasion can be established. Channel-like depressions on this contact may represent thick sands or gravels carrying fresh water. It was only sometimes possible to determine sandy horizons in the Pleistocene from the resistivity data, and then only qualitatively. — D. B. V.

- 184-292. Homma, Ichiro; Hirukawa, Takashi; Kishi, Kazuo; and Noma, Yasuji. Hydrogeological investigation of the water resources in the Ota River basin, Hiroshima Prefecture: Japan Geol. Survey Bull., v. 11, no. 2, p. 117-134, 1960.

The distribution of aquifers in the delta region of the lower Ota River in Hiroshima City, Japan, was determined from borehole and electrical prospecting data. — V. S. N.

ELECTRICAL LOGGING

- 184-293. Tixier, M. P., Alger, R. P., and Tanguy, D. R. New developments in induction and sonic logging: Jour. Petroleum Technology, v. 12, no. 5, p. 79-87, 1960.

A new induction sonde with a radius of investigation twice that of present sondes has been developed for use where deep invasion is present. It has very nearly the same vertical resolution as current models. The characteristics of the new tool are described, and interpretation charts presented. Field examples are also discussed.

The design of sonic logging tools has been modified to improve reliability and to decrease maintenance. Steps are being taken to make calibration fool-proof. The fact that porosity can be recorded accurately by the sonic log has prompted new interpretations. One approach consists of plotting transit time against true resistivity; saturations can thus be estimated conveniently even where formation water resistivity is not well known. In another approach a comparison is made of the values of the formation waters computed from the resistivity and sonic logs. This procedure makes possible a quick determination of zones of saturation in shaly sands or where the formation salinities vary appreciably with depth. — J. W. C.

- 184-294. de Witte, L[eendert]. Discussion of "Log interpretation in sandstone reservoirs" by M. R. J. Wyllie, Geophysics, August 1960, p. 748-778; Geophysics, v. 26, no. 1, p. 101, 1961.
Wyllie, M. R. J. Reply to discussion by L. de Witte on "Log interpretation in sandstone reservoirs": *ibid.*, p. 102, 1961.

In the paper in question (see Geophys. Abs. 182-199), Wyllie stated that A. J. de Witte's method of determining percentage of water saturation pro-

posed in 1957 (see *Geophys. Abs.* 169-109) has not been widely used because its derivation was intuitive rather than theoretical. It is pointed out that the relations proposed by de Witte and confirmed by Wyllie's data were published by L. de Witte in 1955, derived by a coherent and concise theoretical treatment of the electrochemical behavior of shaly sands (see *Geophys. Abs.* 164-120). Field results showing the applicability of L. de Witte's shaly sand relations to the determination of resistivity index and connate water saturation were also reported by Blum and Martin in 1955 (see *Geophys. Abs.* 164-122).

In reply, Wyllie states that the paper by A. J. de Witte was cited because it was presented in a form well suited to practical use, and in that paper it was pointed out that the basic equations, although similarly derived, were identical to those in the L. de Witte's earlier work. The latter, however, does not constitute a complete treatment of the problem, either. — D. B. V.

- 184-295. Slack, Howard, and Otte, Carel. Electric log interpretation in exploring for stratigraphic traps in shaly sands: *Am. Assoc. Petroleum Geologists Bull.*, v. 44, no. 12, p. 1874-1894, 1960.

Two quantities which can be calculated from conventional electric logs of shaly sands, shaliness and saturation ratio, provide useful information on the reservoir rock and the fluid it contains. The values of shaliness and saturation ratio when viewed together are related to the performance of the formation under production tests. Definite ranges in values of these quantities are associated with (a) formations which produce hydrocarbons readily, (b) formations which produce commercial quantities only when artificially stimulated, and (c) formations which produce water along with the hydrocarbons.

A single favorability criterion is developed which is a joint function of shaliness and saturation ratio; this criterion, based on electric-log derived quantities, is a numerical estimate of the production performance of a formation. Its use in exploration is demonstrated by maps of its variation in shaly sand reservoirs of several oil fields. It may be of use in detecting the proximity of good oil production from dry-hole data. — D. B. V.

- 184-296. Johnson, Jarl P. How to determine permeability from well log data: *World Oil*, v. 151, no. 7, p. 88-90, 1960.

A method based on well log information is presented for determining formation permeability when core data are not available. The logs used are those commonly employed in salt mud systems; they include focused microdevices (microlaterolog or $F_{OR_{XO}}$), an independent porosity measuring technique (velocity or neutron), and a means of measuring R_t (laterolog or guard). The method as applied to the San Anders formation of western Texas is discussed. A chart is presented by which the apparent residual oil saturation can be ascertained from the logging data. A second chart shows the relationship between the apparent residual oil saturation and permeability. — J. W. C.

- 184-297. Plewa, Stanislaw. Geophysikalische Verfahren zur Feststellung von Kohle in polnischen Bohrlöchern [Geophysical procedures for the determination of coal in Polish boreholes]: *Freiberger Forschungshefte C 81 Geophysik*, p. 94-110, 1960.

Electrical logging was begun in Poland in 1950 and gamma-ray logging in 1952. Neutron-gamma logging was introduced in 1956. The use of combinations of these methods makes it possible to interpret coal sections unambiguously. The results of self-potential, induced potential, resistivity, gamma, neutron-gamma, microlog, and caliper logging are discussed. Numerous examples of logs are reproduced. Thicknesses thus determined are 8-10 percent too high, compared to 14-18 percent too low from core extraction.

Resistivity logs give very good results in determining the location and in some cases the thickness of coal seams in areas where the resistivity of the coal is much greater than that of the surrounding rock (sandstone). Coal seams can be sharply distinguished on neutron-gamma logs, especially when short sondes and intense radiation sources are used. Resistivity logs together with micrologs indicate porosity of the rock and thickness of a coal seam. — D. B. V.

- 184-298. Kaufman, A. A. K obosnovaniyu induktsionnogo karotazha [Basis of induction logging]: Vyssh. Ucheb. Zavedeniy, *Izv. Geologiya i Razvedka*, no. 7, p. 107-114, 1960.

The attempt is made to determine mathematically to what extent the assumptions underlying Doll's induction logging method (see *Geophys. Abs.* 139-11592) correspond to actuality. Differences between results using Doll's methods and those obtained with models are discussed. — J. W. C.

- 184-299. Buryakovskiy, L. A. Opredeleniye pronitsayemosti po karotazhu soprotivleniy [Determination of permeability by resistivity logging]: *Geologiya Nefti i Gaza*, no. 1, p. 47-51, 1959.

A theoretical relationship exists between the permeability (k_{pe}), the thickness of the film of fixed water τ , and the coefficient of increase in resistance R_H of a rock. This relationship is expressed in the formula:

$$k_{pe} = 40\tau^3 \sqrt{R_H^3}.$$

The formula was applied in the Neftyanyye Kamni field, where the resistivity measurements were made with a laterolog. The results of 290 such determinations are presented in a table and compared with data on permeability determined from cores from several of the same horizons. The agreement is good in general. — J. W. C.

- 184-300. Oilweek. New electric well-logging unit: *Oilweek*, v. 11, no. 47, p. 31, 1961.

The development of a new, completely self-contained electric well-logging unit is reported. The unit can be used with standard type probes and can be handled and operated by any driller; it replaces truck-mounted equipment. The tool measures 2 3/4 inches in diameter and 98 inches in length, is completely transistorized, is independent of outside power sources, will operate to a depth of 15,000 feet, and will withstand temperatures in excess of 300 degrees. — V. S. N.

- 184-301. Oil in Canada. New Schlumberger airborne logging unit: *Oil in Canada*, v. 13, no. 15, p. 14, 1961.

An economical and light-weight logging unit which can be easily transported by air to remote and inaccessible well locations is described. The unit is divided into 3 easily reassembled sections: recording equipment, winch, and engine drive. Each weighs 2,000 lbs or less. A multiconductor logging cable of small diameter holds down gross weight but allows running of all types of services to depths as great as 11,000 feet. — V. S. N.

- 184-302. Melik-Shakhnazarov, A. M., and Mel'nikov, A. G. Sistemy teleizmereniya (po metodu intensivnosti) dlya geofizicheskoy apparatury elektricheskogo karotazha [Systems of telemeasuring (by the intensity method) for geophysical apparatus of electrical logging]: *Vyssh. Ucheb. Zavedeniy, *Izv.*, Neft' i Gaz.*, no. 6, p. 129-134, 1960.

Systems of telemeasuring can use either direct or alternating current, and each of these in turn has two variants—balanced and inbalanced types. Most present systems use a direct current of the inbalanced type. All four variants are described and schematic diagrams are given. Recommendations for the use of the various systems are made as follows: With low sonde currents (0.1–10 ma), alternating current should be used. If the current necessary for the input electrode is considerably more than 5 v, it is better to use a direct current. — J. W. C.

- 184-303. Belen'kiy, Ya. Ye., Mikhaylovskiy, V. N., and Svenson, A. N. Mnogokanal'noye teleizmeritel'noye ustroystvo dlya kompleksnykh geofizicheskikh issledovaniy skvazhin [Multichannel telemeter for combined geophysical investigations of wells]: *Geologiya Nefti i Gaza*, no. 1, p. 52–55, 1959.

A multichannel telemeter has been constructed which permits simultaneous measurement of eight values of apparent resistivity and self potential using a standard single-strand cable. Concentration of all the channels into one cable is accomplished with a high-speed circuit electronic commutator which switches the measuring circuit at a frequency of 20 cycles per second. Such a frequency permits logging to be carried out at a rate up to 3,000 m per hr. The sonde is 2.2 m in length and 70 mm in diameter. Schematic diagrams are given of the sonde and receiver circuits, and an example of a log is illustrated. — J. W. C.

- 184-304. Kornfeld, Joseph A. How to choose eastern Oklahoma datum planes: *World Oil*, v. 151, no. 1, p. 124, 126–127, 130–131, 1960.

Selection of key marker reference datum planes in the Lower Pennsylvanian of eastern Oklahoma presents difficulties owing to rapid stratigraphic changes. Since so much production is controlled by stratigraphic traps in this region, correct selection of datum planes is essential in subsurface geological and geophysical exploration. A datum must be regional in extent, geologically reliable, and easily detectable on electric or radioactivity logs. Six key marker datum planes commonly used in eastern Oklahoma are discussed. — J. W. C.

- 184-305. Anpilogov, A. P. Litologicheskaya kharakteristika produktivnykh otlozheniy devona Tuymazinskogo mestorozhdeniya po promyslovo-geofizicheskim materialam [Lithologic characteristics of the productive sediments of the Devonian of the Tuymazy field according to logging data]: *Geologiya Nefti i Gaza*, no. 2, p. 40–44, 1959.

In order to determine the best method for detailed study of well sections in the Tuymazy field, several types of logs were compared with core data. The self potential, microsonde, and caliper logs were found to be the most reliable for distinguishing sandstone, shale, limestone, argillaceous siltstone, and sorted siltstone, provided the beds are greater than 0.5 m in thickness. — J. W. C.

EXPLORATION SUMMARIES AND STATISTICS

- 184-306. Phipps, Rollin E. A case history of the Bronte (Ellenburger) and Rawlings Fields, Coke County, Texas: *Geophysics*, v. 25, no. 6, p. 1167–1183, 1960.

The North Bronte area of the Midland basin, Texas, has been regarded as favorable for oil on the basis of surface, isopachous, and magnetic studies. A seismic survey was made, the results of which were confirmed subsequently by drilling. — J. W. C.

- 184-307. Patrick, Homer G. Geophysical activity in 1958: *Geophysics*, v. 24, no. 5, p. 925-942, 1959.

Worldwide geophysical exploration for oil and gas in 1958 is reviewed. — J. W. C.

- 184-308. Oil in Canada. Exploration—Geophysical work down 16 percent from 1959: *Oil in Canada*, v. 13, no. 8, p. 18, 1960.

Geophysical activity in western Canada and the Northwest Territories declined 16 percent during 1960. A total of 678 crew months were recorded as compared to 808 crew months in 1959. — V. S. N.

- 184-309. Vincenz, S. A. Geophysical exploration in Jamaica—A historical review: *Geonotes*, v. 3, pt. 1, p. 9-17, 1960.

Major geophysical exploration techniques are discussed briefly, and the gravimetric, magnetic, electric, seismic, radiometric, and geochemical surveys carried out to date in Jamaica are described. Most of the surveys have been for the purpose of locating mineral deposits. In the future geophysical techniques will be used to locate ground water and oil, and to continue exploration for metallic minerals. — V. S. N.

- 184-310. World Oil. How the Sahara's geophysical problems are being solved: *World Oil*, v. 152, no. 1, p. 76-77, 1961.

The first broad geophysical coverage of the Sahara started in the early post-World War II years. The gravimeter was used at that time for reconnaissance, but it has now been supplanted by the airborne magnetometer. A general reconnaissance gravity map has been prepared for the entire central Sahara. Good results are reported using telluric current exploration in southern Algeria.

A high signal-to-noise level hampered early reflection work. In later work this difficulty was overcome by using large numbers of geophones and multiple charges. In some regions a spread of 80 geophones per trace and 80 shot holes were used covering 1 hectare (2.471 acres) to obtain a multiplication coefficient of 6,400. Refraction has also been used extensively. — J. W. C.

- 184-311. Knappe, Helmut, and Zeuch, Richard. Über einige neue Ergebnisse geologischer und geophysikalischer Erkundungsarbeiten auf Erdöl in der nordwestlichen Altmark [On some new results of geological and geophysical investigations for petroleum in the northwest Altmark]: *Geol. Gesell. Ber.*, v. 4, no. 2/3, p. 178-182, 1959.

Petroleum investigations in the salt dome area of the northwest Altmark, East Germany, were resumed in 1950 after a 10-yr interval. At the present time a network of seismic reflection profiles has been measured, 9 boreholes (almost all more than 1,500 m deep) have been completed, and 3 more are being drilled. The subdivisions of the Tertiary are determined on the basis of electric logging, as no core was recovered from the boreholes.

Results are presented in the form of logging curves, an isopach map, a reflection profile across two salt domes, and a geologic section of the area between Waddekath and Peckensen. — D. B. V.

- 184-312. Antropov, P. Ya. Osnovnyye zadachi geologorazvedochnykh i poiskovykh rabot na nef't' i gaz v 1959-1965 gg. [Main tasks of geological prospecting and exploration operations for oil and gas in 1959-65]: *Geologiya Nefti i Gaza*, no. 1, p. 1-8, 1959.

Geological and geophysical exploration in the U. S. S. R. during the seven-year plan (1959-65) is discussed. Particular attention is called to the low effectiveness of seismic surveying in locating low amplitude structures on the Russian and Siberian platforms. Further, the work undertaken in the majority of regions at the present time depends on the availability of seismic crews and their equipment rather than on the geological conditions. — J. W. C.

- 184-313. Ayzenshtadt, G. Ye. -A., Nevolin, N. V., and Eventov, Ra. S. O burenii sverkhglubokikh skvazhin v tsentral'noy chasti Prikaspiyskoy vpadiny [Drilling of extra-deep wells in the central part of the Pri-Caspian depression (with English abstract)]: *Sovetskaya Geologiya*, no. 12, p. 33-43, 1960.

Oil and gas exploration in the Pri-Caspian depression requires drilling of extra-deep (up to 7,000 m) wells. This drilling will be coordinated with seismic profiles and aeromagnetic surveys. — J. W. C.

- 184-314. Borisov, A. A. O metodike i rezul'tatakh rabot po sostavleniyu regional'noy strukturnoy karty Turkmenii po geofizicheskim dannym [On the methods and results of preparation of the regional structural map of Turkmenia according to geophysical data]: *Prikladnaya Geofizika*, no. 24, p. 190-212, 1960.

The use of gravity, magnetic, and electrical surveys in the preparation of a structural-geological map of the Turkmen S. S. R. is reported. — A. J. S.

- 184-315. Dneprov, V. S. Neftyanye mestorozhdeniya i razvedochnyye ploshchadi Embenskooy neftenosnoy oblasti [Oilfields and exploration areas of the Emba oil-bearing district]: *Vses. Neft. Nauchno-Issled. Geol. Razved. Inst. Trudy*, no. 138, 275 p., 1959.

The Emba salt dome district, which lies to the northeast of the Caspian Sea, is discussed. Short descriptions are given of the geology, the history of geophysical and geological exploration, and the oil prospects of 15 oilfields and of the 38 exploration areas (36 salt domes and 2 interdome areas) that have been prospected. — J. W. C.

- 184-316. Central Water and Power Research Station Poona. Geophysical investigations at Chandan dam site: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., p. 67-68, 1959.

Seismic refraction and electrical resistivity surveys were made at the site of the proposed dam on the Chandan River, South Bihar, India, to locate a suitable site for a spillway along the left bank. Estimated depths to bedrock and structure contours are shown on a map. — V. S. N.

- 184-317. Shimura, Kaoru. Ground water survey at the foot of the west and east slopes of Mt. Fuji [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 46-64, 1960.

A compilation of results from a study since 1946 of ground water resources at the foot of the east and west slopes of Mt. Fuji, Japan, is presented. The mode of occurrence of the ground water in relation to the geologic structure as determined from geophysical surveys is discussed. — V. S. N.

- 184-318. Geological Survey of Japan. History and present status of geophysical prospecting in Japan, in *Geology and mineral resources of Japan* (2d ed.): Kawaskai, Japan, Japan Geol. Survey, p. 185-304, 1960.

A brief historical review is presented of approximately 20 years of geophysical prospecting in Japan. Diagrams show the percentage of application of each geophysical method to four general fields. A general discussion of the application of geophysical methods to specific problems is given in 7 short chapters as follows: prospecting for oil and natural gas; prospecting for coal; prospecting for radioactive minerals; prospecting for metallic and nonmetallic minerals; prospecting for ground water; prospecting for natural steam and hot springs; and applied geophysics in civil engineering. — V. S. N.

GENERAL

184-319. Jacobs, J. A., Russell, R. D., and Wilson, J. Tuzo. *Physics and Geology*: New York, McGraw-Hill, 424 p., 1959.

This book is an outgrowth of courses on the physics of the earth given for senior undergraduates and graduate students, and, as a consequence, has two aims: (1) To give students of geology an introduction to the physics of the earth; and (2) to give scientists in other fields some knowledge of geology and its relation to geophysics.

The text contains 17 chapters as follows: The universe and the solar system; seismology and the interior of the earth; composition of the earth; the figure of the earth and gravity; thermal history of the earth; geomagnetism; physics of the upper atmosphere; geochronology; isotope geology; mechanical behavior of earth materials; investigation of the ocean floors; the ocean floors; the mid-ocean ridges; island arcs and mountains; inactive mountains and continents; origin of the earth's surface features; and glaciology. The 6 appendixes are as follows: derivation of velocity-depth curves from traveltime tables; Clairaut's theorem; motion of a single charged particle in the earth's magnetic field; isotopic equilibria; the dynamics of faulting; and crevasses and crevasse patterns. — V. S. N.

184-320. Gassmann, Fritz, and Weber, Max. *Einführung in die angewandte Geophysik* [Introduction to applied geophysics]: Bern, Verlag Hallwag, 284 p., 1960.

The first chapter of this introductory book reviews applied geophysics describing the methods in general, fundamentals in planning operations, economic factors, and historical background. The second chapter deals with gravity exploration; measurement, reduction, and interpretation are treated. The third chapter is devoted to magnetic surveying; the static magnetic field, earth magnetism, magnetic measurements, rock magnetism, and interpretation of magnetic disturbance are discussed successively. The fourth chapter is on seismic surveying and consists of discussions on elasticity, reflection and refraction surveying, and seismographs. The fifth chapter deals with electrical exploration. — J. W. C.

184-321. Laver, F. J. M. *Waves*: London, Oxford Univ. Press, 77 p., 1959.

The types, form, and behavior of waves are discussed in 18 chapters. The first 3 chapters deal with the general nature of a wave and some of the different kinds of waves. The next 9 chapters discuss the behavior of waves including speed and force; echoes, reflections, and interferences; shadows; mixing and separating; and vertical and horizontal motion. Specific types of waves are discussed in 4 chapters—water, sound, earthquake, and electromagnetic waves. The book is concluded with a chapter on waves in general and a list of references. — V. S. N.

- 184-322. Shapley, A. H. International Geophysical Calendar for 1961: Science, v. 132, no. 3444, p. 1941-1943, 1960; also in Am. Geophys. Union Trans., v. 41, no. 4, p. 722-728, 1960; Jour. Geophys. Research, v. 65, no. 1, p. 336-339, 1960; and Nature, v. 189, no. 4758, p. 9-11, 1961.

A committee under the International Council of Scientific Unions has issued a calendar for 1961 to encourage worldwide coordination of observations or analysis of those phenomena which vary significantly during the course of a year. These phenomena are mainly in the disciplines dealing with the earth's atmosphere. Three consecutive days each month are designated Regular World Days, intended for programs that can be carried out only about 10 percent of the time and for any unusual or special experiments. Regular World Intervals are 10 consecutive days each quarter, selected to include the Regular World Days of the month, the times of equinox and solstice, and if possible days of solar eclipse and meteor showers. World Meteorological Intervals are also 10 consecutive days each quarter, and International Rocket Weeks are two periods during the year when rocket studies of the atmosphere and of the sun will be on as nearly a synoptic basis as is possible at present. — D. B. V.

- 184-323. Gerson, N. C. From Polar Years to IGY, in Advances in geophysics, v. 5: New York, Academic Press Inc., p. 1-52, 1958.

The development of the International Polar Years culminating in the International Geophysical Year is reviewed. The discussion includes a history of the concept; observations and results of the First and Second International Polar Years; the objectives, general program implementation, scientific program, world data centers, and preliminary results of the International Geophysical Year of 1957-58; and the future of the International Years. A list of 95 references is included. — V. S. N.

Wertheim, Gunther K. The Mössbauer effect: a tool for science. See Geophys. Abs. 184-368.

- 184-324. Komarov, S. G., and Per'kov, N. A. Ob oboznacheniiyakh velichin, ispol'zuyemykh v promyslovoy geofizike [On designation of quantities used in applied geophysics]: Prikladnaya Geofizika, no. 21, p. 211-222, 1958.

A table of 94 symbols and their subindexes used in applied geophysics is given. Differences in symbols used in the United States, in the U. S. S. R. (Moscow Petroleum Institute), and other countries are brought out, and a uniform designation of geophysical quantities is recommended. In the discussion that precedes the table some terms of applied geophysics are given in Russian and English. — A. J. S.

- 184-325. World Petroleum. New tools for the geophysicist: World Petroleum, v. 31, no. 3, p. 48-54, 57, 60, 62, 64, 66, 70, 1960.

A brief review of previously published information on new equipment and techniques developed during the past year for both aerial and marine reconnaissance geophysical exploration is presented. The following instruments are discussed: the airborne gravimeter, the continuous marine profiler, the marine seep detector, the stratigraph (originally called the summarizer), the nuclear magnetism log, the time base and d-c amplifier, the Decatrack, the ABEM MZ-4 magnetometer from Sweden, the Keyboard Input Unit, the single revolution Omnitape, miniature and refraction geophones, and the PMR-20 magnetic recording system. — V. S. N.

- 184-326. Morrison, L[aurence]S. , and Watson, Robert. The electronic computer and geophysics: *Geophysics*, v. 26, no. 1, p. 40-44, 1961.

The principles of electronic computers are reviewed briefly. Such computers have been used in geophysical exploration to compute and contour derivative maps of gravity and magnetic data, to reduce gravity data to datum, to compute interval and average velocities from velocity profile data, and to solve many nonrecurring problems. — D. B. V.

- 184-327. Schedler, George D. Land geophysical techniques in oil exploration: *Philippine Geologist*, v. 14, no. 2, p. 73-80, 1960.

The application of seismology, magnetism, and gravity to exploration for oil on land is briefly reviewed. The basic principles underlying each technique and the factors influencing the interpretation of data are discussed. — V. S. N.

- 184-328. Shirokov, A. S. , and Fedyuk, V. I. O primenenií geofizicheskikh metodov pri razvedke rudnykh mestorozhdeniy [Application of geophysical methods in prospecting for ore deposits]: *Razvedka i Okhrana Nedr*, no. 3, p. 28-38, 1960.

Methods of electric, magnetic, gravity, seismic, and radiometric prospecting and logging are discussed briefly. — A. J. S.

- 184-329. Onodera, Toru. General note on the geophysical prospecting in the Construction Ministry, especially on the dynamic method of determining Young's modulus of rocks in situ [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 1, p. 65-72, 1960.

The methods of geophysical and chemical prospecting used by the Ministry of Construction in Japan for inspecting and testing each stage of any civil engineering construction are listed. A general description is given of some of the newer radioactive prospecting methods for the investigation of migration of littoral sands, fluvial loads, groundwater movements, and other such processes. The method of determining the Young's modulus of elasticity on foundation rocks in place is described and examples presented. The application of Young's modulus to the investigation of the consolidation of grouting is also discussed. — V. S. N.

- 184-330. Electronics. Russian television inspects wells: *Electronics*, v. 34, no. 13, p. 22, 1961.

A picture shows a television pickup unit for inspection of the sides of boreholes. Semiconductors and miniature components are used. The housing is 1,690 mm long and 60 mm in diameter. — J. W. C.

- 184-331. Lishman, J. R. The increasing value of well logging information: *Canadian Oil and Gas Industries*, v. 14, no. 1, p. 53-56, 1961.

Recent advances in well-logging techniques and in interpretation of the logs are discussed. The various methods treated are acoustic velocity, gamma-gamma density, resistivity, nuclear magnetism, spectrographic radioactivity, and acoustic attenuation. — J. W. C.

- 184-332. Nechvíle, Jiří. Bohrloch-Neigungsmesser mit Kreiselorientierung [Borehole inclinometer with gyroscopic orientation]: *Freiberger Forschungshefte C 81 Geophysik*, p. 80-93, 1960.

The IG 70 borehole inclinometer is described. With this model it is possible to measure the angular coordinates of any number of points in one down-hole trip of the sonde. Because the instrument is oriented by means of a gyroscope rather than by the usual magnetic needle, accuracy is not affected by the casing or by the magnetic properties of the wall rock. The diameter of the sonde is only 70 mm, permitting its use in a large majority of boreholes. A wiring diagram and photographs of the instrument are given, and the measuring procedure is described and illustrated by field examples. — D. B. V.

- 184-333. Decker, Robert W. Geophysics in Indonesia, 1921-1961: Univ. Indonesia, Inst. Technology Bandung, Dept. Geology Contr., no. 35, 27 p., 1960.

The history and results of geophysical activity in Indonesia since 1921 are summarized, its present status is described, and possible directions for research and application are suggested. The subjects covered (seismology, gravity, tectonophysics, magnetism, and other physical properties) are discussed mainly from the standpoint of the accomplishments of each scientist who has contributed to these fields in Indonesia. A comprehensive bibliography is included with each section. — V. S. N.

- 184-334. deMille, G. The Elbow structure of south-central Saskatchewan: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 5, p. 154-162, 1960.

The Elbow structure in south-central Saskatchewan, discovered during a seismic survey for oil, is a symmetrical dome in Mesozoic rocks beneath which lies a cylindrical mass of broken Paleozoic rock. The structure is marked by a positive gravity anomaly that reflects the dome form and the upward displacement of the disturbed Paleozoics; this is further confirmed by deep drilling. Two episodes of deformation are indicated: (1) Post-Mississippian explosive activity which dislocated and displaced the Paleozoic rocks, and (2) Tertiary displacement resulting in upward movement of the broken Paleozoic rocks to form the unbroken dome in the Mesozoic strata. The Elbow structure is considered to be a modified cryptovolcano probably produced by super heated steam and not by the emplacement of high density or magnetically susceptible rock; the structure could not be located on a detailed aeromagnetic map.

A similar but smaller structure, the Gilroy structure, lies about 4 miles south of Elbow. It is not indicated by a gravity anomaly but is considered to be a cryptovolcanic structure. — V. S. N.

GEODESY

- 184-335. Hirvonen, R. A. The size and shape of the earth, in *Advances in geophysics*, v. 5: New York, Academic Press Inc., p. 93-115, 1958.

A general review of the problems concerned and of the precision obtainable with modern instruments and methods is given for each of the four groups—triangulation, astronomical fixations, spirit leveling, and gravity measurements—of principal geodetic observations for precise determination of the form of the earth. A new general theory of geodesy is outlined for the treatment of the combination of these four groups designed to avoid the drawbacks of Stokes' theory by deriving the integral formula for the physical surface of the earth rather than for the geoid or cogeoid. A list of 40 references is included. — V. S. N.

- 184-336. Ledersteger, Karl. Zur theorie des Normalsphäroides der Erde [On the theory of the normal spheroid of the earth (with English summary)]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 36, p. 3-20, 1960.

An attempt is made to solve Clairaut's problem of inhomogeneous spheroidal equilibrium figures without any assumption concerning mass distribution by studying the possible linear series of these equilibrium figures. It is shown that the normal spheroid is defined by the earth's mass E , velocity of rotation ω , principal moment of inertia C , and the 4th-order mass function D . At sufficient heights above the earth's surface the level surface will hardly differ from the pertinent equipotential spheroid; within such a level surface there is only one equilibrium figure that is identical with the normal spheroid. The numerical computation of the normal spheroid is based on the velocity of rotation and dynamic flattening, which can be substituted for the static flattening by going back to the original ellipsoid of the homogeneous series (ω, K) of equilibrium figures, and on the assumed equatorial values of gravity and radius.

A purely hypothesis-free solution of the problem of the normal spheroid is not possible, but it gives valuable information about the solution of the total problem of the figure of the earth. The two parts of the problem—derivation of the normal spheroid and its coaxial mean earth ellipsoid, and determination of the absolute geoid undulations—can be solved almost without assumptions by mutual penetration. The substitutions described above then become superfluous. — D. B. V.

- 184-337. Ledersteger, Karl. Die theoretische Lösung des gesamt Problem der Erdfigur [The theoretical solution of the total problem of the figure of the earth (with English summary)]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 36, p. 21-30, 1960.

A hypothesis-free solution of the earth's figure on a strictly physical basis requires simultaneous determination of the normal spheroid and geoid undulations. As the real vertical gradient of gravity outside the earth is not known accurately, the artificial "free-air" geoid must be interposed. Gravity distribution and the indirect effect can be derived accurately for the free-air geoid without assumptions as to mass displacements. The pertinent equipotential spheroid is either a level outer surface or the free surface of the normal spheroid that has to be determined. The heights N of the free-air geoid above the equipotential spheroid can be calculated from the free-air gravity anomalies via Stokes' integral, giving the ellipsoid of revolution coaxial with the equipotential spheroid. From the elevations $z=(N+h-c)$ of the actual geoid above this ellipsoid the "absolute adjustment of deflections of the vertical" gives the correction of the axis together with absolute location of the net, and the relative position of the continents separated by oceans.

It can be confirmed that the equipotential spheroid obtained is identical with the normal spheroid. The formula obtained for theoretical gravity on the normal spheroid is easily transformed by means of the free-air gradient into the coaxial ellipsoid of revolution, which is the mean earth ellipsoid. The main advantages of this strictly physical procedure are the elimination of the artificial equipotential ellipsoid and an exact connection, based on potential theories, of gravity anomalies and geoid undulations with irregularities of mass distribution in the crust. — D. B. V.

- 184-338. Ledersteger, Karl. Die geometrischen und physikalischen Daten des Normal-sphäroids der Erde [The geometric and physical data of the normal spheroid of the earth]: Bayerische Akad. Wiss. Sitzungsber. Math.-Naturw. Kl., v. 1959, p. 23-39, 1960.

At present the so-called "International Approximation System," based on the Hayford Ellipsoid and on the international gravity formula, is generally applied in determining the normal figure of the earth. It is becoming increasingly obvious that this approximation system is in need of revision, not only with respect to its numerical values, but even more because it represents a physically improbable figure. Various shortcomings of the system are discussed, chiefly in mathematical terms. — D. B. V.

- 184-339. Ledersteger, Karl. Die gravimetrische Methode zur Bestimmung der Erdfigur [The gravimetric method of determination of the earth's figure]: Bayerische Akad. Wiss. Sitzungsber., Math. - Naturw. Kl., v. 1958, p. 117-136, 1958.

A method is developed mathematically for calculating the normal spheroid of the earth. This new solution avoids the assumption of the value $\delta = +105 \times 10^{-7}$ used in an earlier work, and uses the empirically determined value of β_4 instead. (See Geophys. Abs. 174-158, -159.) — D. B. V.

- 184-340. Heiskanen, W. A. Achievements and limitations of the gravimetric method in geodesy: Deutsche Geod. Komm. Veröffentl., ser. A, no. 32, p. 9-22, 1959.

Recent applications of the gravimetric method to geodesy, carried out at the Ohio State University Institute of Geodesy, Photogrammetry and Cartography, are summarized. The principles, prerequisites, and practical procedures involved are outlined. The 1957 Columbus geoid for Europe, although preliminary, is the most complete geoid published so far; it is illustrated in two figures. The 1959 Columbus geoid will cover a larger portion of the earth's surface and will be more accurate.

Limitations of the gravimetric method are practical rather than theoretical. The desirability of continuous international cooperation is stressed. — D. B. V.

- 184-341. Gerke, Karl. Stand der westdeutschen geodätischen Schweremessungen und Schwerekarten 1958 und Vorschläge für die weiteren Arbeiten [State of West German geodetic measurements and gravity maps in 1958 and proposals for further work]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 32, p. 24-30, 1959.

The status of geodetic gravity measurements and gravity maps of West Germany as of 1958 is reviewed. Progress in surveying and determination of mean altitudes for central Europe is shown on maps, and a sample of the gravity data form sheet is reproduced. — D. B. V.

- 184-342. Bodemüller, Hellmut. Höhensysteme, ihre Definition und ihre gravimetrische Bestimmung [Altitude systems, their definition and gravimetric determination]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 32, p. 32-40, 1959.

Different systems of determining orthometric and dynamic (geopotential) heights and their approximations for practical purposes are reviewed and the question of the best method is discussed. It is concluded that geopotential heights should be used for all main lines of official altitude networks and could be used for intermediate lines wherever local gravity measurements have been made. Orthometric heights should be determined from the fixed altitude points. For ordinary purposes the Vignal-Molodenskiy approximation has no advantages over Helmert's method. Raw altitude differences can be used in technical levelings so long as they provide a sufficiently close approximation of Helmert's heights. — D. B. V.

- 184-343. Wolf, Helmut. Gravimetrisch-astronomische Punktbestimmung und Triangulation [Gravimetric-astronomic location of points and triangulation]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 32, p. 46-52, 1959.

The gravimetric-astronomic absolute method of locating points and the relative method of triangulation are compared, and ways of utilizing the advantages of each for geodetic purposes are discussed, particularly in regard to the ultimate goal of the world geodetic system: to assign every point on earth to a definite place on a reference surface valid for the earth as a whole. — D. B. V.

- 184-344. Ramsayer, Karl. Genauigkeitsuntersuchungen der Schwerereduktion von Nivellements [Investigations of the accuracy of the gravity reduction of leveling]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 31, 50 p., 1959.

In the calculation of geopotential heights, errors appear that are due to errors in interpolation and measurement of altitudes and of gravity. On the basis of sectors totaling 845 km in length, a system of formulas has been developed which permits the calculation of the effect of these sources of error on the geopotential height differences as a function of the mean altitude differences per kilometer and the average spacing of gravity stations. In addition, formulas are derived for calculating the permissible gravity station spacing. The formulas are valid for plains, hilly areas, and "Mittelgebirge." — D. B. V.

- Heiskanen, W. A. Assembly of gravity data. See Geophys. Abs. 184-375.

GEOTECTONICS

- 184-345. Belousov, V. V. Development of the earth and tectogenesis: Jour. Geophys. Research, v. 65, no. 12, p. 4127-4146, 1960.

Tectogenesis reflects the development of the earth under the influence of radioactive heating. The accumulated heat is removed partly by melting and differentiation of the mantle material. Melting took place first in the upper layers of the mantle; this is the granite stage of tectogenesis, during which there takes place geosynclinal platform development of the crust, with wavelike oscillatory movements. In this process the crust is filled with granitic material.

Later, melting occurs in a deeper mantle layer, whence superheated basalt rises to the surface. In this stage tectonic activity takes place and the granite crust is eventually destroyed and "oceanization" occurs. Thus, elevations and depressions of the crust, developed in the course of wavelike oscillatory movements, and sea depths of mediterranean type (located on oceanic crust) and oceans are the result of genetically different processes. The basic difference between them is that the movements of the former type are compensated by accumulation of sediments and erosion whereas the second type are not.

All these processes proceed irregularly both in time and space. Melting does not occur simultaneously over the whole mantle, but in separate focuses; as these migrate the whole layer is ultimately involved. The activity of individual deep faults, which are very influential in the melting process and in vertical movements of mantle material, is also different at different times. Irregularity in space is expressed by the fact that different parts of the earth's surface may be in different stages of development at the same time; this increases the complexity and variety of crustal structure but also affords an opportunity to review the history of the crust by comparative studies of the different regions. — D. B. V.

- 184-346. Belousov, V. V., and Rudich, Ye. M. O meste ostrovnykh dug v istorii razvitiya struktury zemli [Place of island arcs in the history of development of the structure of the crust (with English abstract)]: Sovetskaya Geologiya, no. 10, p. 3-23, 1960.

The ocean basins are regarded as secondary structural features that have formed as a result of destruction and basification of continental crust. This process is attended by tension, deep faulting, and strong basaltic volcanism. Two types of island arcs are distinguished. The first is represented by folded ranges similar to continental folded arcs. They are formed in geosynclines, and their development is paralleled by subsidence of the adjacent area on the side toward the continent. These geosynclinal areas become weakened due to tension, and the resulting fractures lead to extensive volcanism. Arcs of the second type are not related to geosynclines but are formed in an oceanic environment as a direct result of tension.

The basification of the earth's crust and the formation of the oceans is the last known stage in the development of the earth determined by the radioactive warming of the interior and the smelting to the surface of material from the mantle. — J. W. C.

- 184-347. Goryachev, A. V. Nokotoryye osobennosti noveyshey tektoniki Kuril'skoy ostrovnoy dugi [Some features of the recent tectonics of the Kurile Island arc (with English abstract)]: Sovetskaya Geologiya, no. 10, p. 24-41, 1960.

On a basis of seismic, gravity, and other geophysical and geological data on the Kurile Island arc, it is concluded that the central portion of the arc is characterized by a high rate of Quaternary downwarping (reflected in deformation of a denudation surface on the Kurile Range), increased volcanic activity and decreased seismic activity, minimum total values of energy of weak earthquakes, positive gravity anomalies, and a type of crust transitional from continental to oceanic. The region is regarded as being in the opening phases of a general oceanization process. — J. W. C.

- 184-348. Noble, Donald C. Stabilization of crustal subsidence in geosynclinal terranes by phase transition at M: Geol. Soc. America Bull., v. 72, no. 2, p. 287-291, 1961.

Isostatic calculations indicate that a mechanism of geosynclinal subsidence based on a phase transformation at the M-discontinuity possesses an inherent stability that will tend to maintain the upper surface of sediments near sea level regardless of fluctuations in the rate of geoisotherm depression or in the rate of sedimentation. This effect may help in the understanding of sedimentation in geosynclinal and stable-shelf terrane. — Author's abstract

- 184-349. Shibata, Isamu. Recent achievements in the seismic researches of the crust and some tectonic interpretations of crustal structure derived from them [in Japanese with English abstract]: Jour. Geography [Tokyo], v. 69, no. 3, p. 10-22, 1960.

Information on crustal structure as determined from seismic research in various parts of the world has been compiled and is presented in a table. The main crustal layers (seismic velocity layers) appear to show a gradual variation in their development according to their position in relation to the major physiographic divisions of the earth, that is, mid-continental, marginal, off-continental, and oceanic. The geologic and petrologic characteristics of these seismic crustal layers are discussed, and some tentative interpretations based on current theories in tectonics, geophysics, and other earth sciences for ma-

for variations of crustal layers and structures are presented. The variation of the upper crustal layers is attributed mainly to the magnitude and age of the tectonic cycles during which they were formed. The major variation of lower crustal layers, common to continental and oceanic regions, has resulted ultimately from the original variation of the material from which they were derived in the above mentioned major earth provinces. A short discussion on the origin of magmas is also included. — V. S. N.

- 184-350. Borisov, A. A. Anomalii sily tyazhesti gornyykh oblastey [Gravity anomalies of mountain regions]: Prikladnaya Geofizika, no. 21, p. 84-103, 1958.

Topographic relief and corresponding variations in Bouguer anomalies at the surface of the earth are correlated with the amplitude of Neogene and Anthropogene tectonic movements in the crust. These phenomena are believed to be due to a variation in density arising from relative compression or expansion in the deep interior of the earth. The parts of the earth's lithosphere in which a rarefaction takes place are characterized by crustal uplift and negative anomalies. An increase in density in the lithosphere leads to a subsidence of the region and positive anomalies. An attempt is made to interpret profiles of the Mediterranean, Carpathian, Crimean, central Caucasus, southeastern Caucasus, central Asian, Indonesian, and Siberian regions by tectonic processes in the crust and upper mantle (300-500 km deep). The mechanism of such changes is shown diagrammatically.—A. J. S.

- 184-351. Subbotin, S. I. Do pytannya pro mekhanizm formuvannya prohyniv zemnoyi kory i pro tektoniku fundamentu Dniprovs'ko-Donets'koyi zapadyny [On the problem of the formation of depressions in the earth's crust and of the structure of the basement of the Dnieper-Donets basin (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 18, no. 6, p. 3-16, 1958.

Depressions in the earth's crust such as the Dnieper-Donets basin form as a result of intermittent compression of the material of the upper part of the mantle, related to polymorphic changes. The compression leads to the appearance of a zone of decreased pressure immediately below the crust, to melting, and to downwarping of the bottom of the crust. When the limit of rigidity of the crust is exceeded deep fractures are formed; subsidence along these may produce grabens, and the magma can rise along them to the surface. In the Dnieper-Donets basin the block structure of the Devonian, Carboniferous, and possibly part of the Permian formations, the complicated structural relations of the different sedimentary complexes of all ages, and the occurrence of the complicated and varied salt tectonics are all due to differential movements between basement blocks. — D. B. V.

- 184-352. Peive [Peyve], A. V. Fractures and their role in the structure and development of the earth's crust: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 280-286, 1960.

The spatial, historical, and genetic associations of many geologic phenomena can be explained in terms of the interrelations of crustal blocks of different composition, shape, and size. According to the degree of fracturing and mobility, the crust is divided into geosynclines and platforms. The large blocks are bounded by large, long-lasting deep fractures along which are located belts of basement shattering, folding of the cover, metamorphism, magmatism, and orogenesis.

The three main types of displacement along these deep fractures are faulting, overthrusting, and shifting. In geosynclinal areas tangential strains and

dislocations predominate. Magma sources are genetically associated with the lower boundaries of blocks, some tens of kilometers below the surface; they are connected to the surface by radial fractures. — D. B. V.

- 184-353. Quiring, Heinrich. Rindenmächtigkeit und Entstehung der Tiefseegräben und Vulkane des Nordpazifik [Crustal thickness and origin of the deep sea trenches and volcanoes of the North Pacific]: *Forschungen und Fortschritte*, v. 34, no. 6, p. 164-167, 1960.

The lack of sialic crust and the special character of the oceanite magmas in the north Pacific Ocean indicate a catastrophic event which tore away a 16-km-thick section of sial and allowed ultrabasic magma to fill the resulting depression up to the level of isostatic compensation. It is suggested that this event was the separation of the moon and the earth. The shortening of the earth's radius by 42 km that resulted from the removal of the moon's mass caused the Laurentian revolution. — D. B. V.

- 184-354. Higgins, Charles G. San Andreas fault north of San Francisco, California: *Geol. Soc. America Bull.*, v. 72, no. 1, p. 51-68, 1961.

Present positions on opposite sides of the fault trace of areas that appear to have been marine entrances to Middle Pliocene basins east of the fault trace suggest that right-lateral displacement along the San Andreas fault north of San Francisco has not exceeded 15 miles, more likely has amounted to 4-10 miles, and possibly has not exceeded $1-1\frac{1}{2}$ miles since Middle Pliocene time. During the same time, vertical movements have raised the east side of the fault about 500 feet relative to the west in some areas, possibly everywhere north of Bolinas. This vertical component maybe attributable to movements on some other branching fault rather than on the San Andreas fault itself. — D. B. V.

- 184-355. Svoboda, Karel. Les mouvements de l'écorce terrestre et leur observation géodésique [Movements of the earth's crust and their geodetic observation]: *Bull. Géod.*, no. 56, p. 211-224, 1960.

Large-scale movements of the earth's crust (epeirogenic, orogenic, tectonic, seismic, and tidal) are discussed. After consideration of the main sources of energy of such movements, their magnitude, and methods of measuring them (particularly geodetic), examples from Czechoslovakia are given with a map of isobases. It is concluded that horizontal and vertical, positive and negative movements are taking place all over the world, most noticeably in regions of young tectonics, and that in seismically active areas the direction of these movements may change. The movements produce stresses in the crustal rocks. When sufficient potential energy has accumulated as elastic stress, a minor impulse may suffice to transform it to kinetic energy; this produces rock pressures, shocks, and structural adjustments in rocks, leading in turn to secondary movements. As the movements are a function of time, changes in stress and rock deformations and their consequences appear to be a function of time. — D. B. V.

- 184-356. Sinyagina, M. I. Preliminary conclusions on vertical movements of the earth's crust determined by means of levelling: *Bull. Géod.*, no. 52, p. 62-68, 1959.

Work was started in 1954 in the U. S. S. R. to establish a high-precision levelling network to indicate geologic and geomorphic conditions of various regions. At present 33,412 km of lines have been surveyed in the Baltic, Black Sea, and Azov Sea areas; of this, 21,767 km were levelled by modern methods

and 11,645 km by the old instructions of 1883. A map of recent tectonic movements over the western half of the European part of the U. S. S. R. has been compiled with isolines based on adjusted values of rate of movement determined from the geodetic data supplemented by oceanographic (tide gauge), geologic, and geomorphic data. Investigations in the Dūna (Dvina) valley are cited as a typical study of recent tectonic movements. — D. B. V.

- 184-357. Meshcherikov, J. A. [Meshcheryakov, Yu. A.]. Secular crustal movements of the East European Plain and associated problems: Bull. Géod., no. 52, p. 69-75, 1959.

This is virtually the same as the paper published in Bur. Central Séismol. Internat. Pubs., Sér. A, Travaux Sci., no. 20, p. 261-275, 1959 (see Geophys. Abs. 182-271). — D. B. V.

- 184-358. Rastvorova, V. A. Sopostavleniye noveyshikh dvizheniy i regional'nogo gravitatsionnogo polya Kavkaza [Comparison of recent movements and the regional gravity field of the Caucasus (with English summary)]: Moskov. Obshch. Ispytateley Prirody Byull. Otdel Geol., v. 35, no. 2, p. 38-42, 1960.

As a result of comparison of the character of recent tectonic movements with the regional gravity field of the Caucasus, a discordance was established between near-surface and deep-seated interfaces. On this basis the processes of formation of near-surface interfaces are assumed to lag behind the processes that take place beneath the crust. — J. W. C.

- 184-359. Grechishchev, Ye. K. Metody otsenki sovremennykh tektonicheskikh dvizheniy na Baykal [Methods of estimating recent tectonic movements in Baikal]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 59-64, 1960.

The amount of recent tectonic movement in the Lake Baikal region is within the limits of accuracy of present releveled surveys. In order that future estimates of deformation may be more reliable, a number of recommendations are made concerning the establishment of a first-order leveling network around the lake, and more and better equipped stations for measuring water-level fluctuations. — D. B. V.

- 184-360. Sato, H[isashi]. Variation of mean tide level around the coast of Shikoku Island [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 2, p. 55-61, 1960.

The results of study of tidal data from 1947 through 1957 along the coast of Shikoku, Japan, show that the tidal level has had a tendency to be regular with the highest ascent occurring along the Hiuchinada coast and the lowest descent along the coast of Tosa Bay. In 1950, the earth tilting caused by the Nankaido earthquake of December 1946 ceased for a time. The variations of sea level for each year are shown in figures. — V. S. N.

- 184-361. Suggate, R. P. The interpretation of progressive fault displacement flights of terraces: New Zealand Jour. Geology and Geophysics, v. 3, no. 3, p. 364-374, 1960.

The vertical and horizontal components of individual movements in a sequence of progressive displacements of flights of river terraces in New Zealand can be deduced according to a stated rule. Applied to the Wairau River, it is concluded that downcutting and faulting do not show the linear relation

deduced by Wellman, but that the rate of faulting has been substantially uniform while the rate of downcutting has diminished. Where the depositional surfaces typical of the highest of many terrace flights represent the principal outwash aggradation surfaces of the last glaciation, the age is thought to be closer to 20,000 yr than to the 10,000 yr previously estimated. Rates of fault movement would then be correspondingly halved; the average rate of horizontal movement probably has not exceeded 0.125 in. per yr, and vertical movement probably has not exceeded 0.006 in. per yr. — D. B. V.

Menard, H[enry] W. The East Pacific Rise. See *Geophys. Abs.* 184-587.

GLACIERS

- 184-362. Kinoshita, Seiiti. The relation between the deformation velocity of snow and the types of its deformation, III [in Japanese with English résumé]: [Hokkaido Univ.] *Low Temperature Sci.*, ser. A, no. 19, p. 135-146, 1960.

In Kinoshita's earlier laboratory studies (1950, 1958) on plastic and destructive deformation of snow under compression at constant speeds v of different magnitudes, it was found that a snow pillar undergoes destructive compression when v is above a certain critical speed and plastic compression when v is below that critical speed. This paper discusses how stress, induced within the snow by compression, changes with time; the general features of the stress-strain, strain-rate curves; the relation between stress relaxation and strain rate; and the effect of the water content of snow on the critical speed. — V. S. N.

- 184-363. Kojima, Kenju. Viscous flow of snow cover deposited on a slope [in Japanese with English résumé]: [Hokkaido Univ.] *Low Temperature Sci.*, ser. A, no. 19, p. 147-164, 1960.

A study of the behavior of viscous flows of snow deposited on a uniform slope is reported. Mathematical expressions are derived for the components of displacement of snow at a height Z during a time interval Δt . In 1959 and 1960 actual measurements of the components were made of snow layers on two slopes of different angle. The method of measuring the deformation of the vertically cut snow and the displacement of each portion over a set time interval is described and illustrated. The direction of displacement of every part of the snow cover on a slope was found to be almost parallel. The angle between the direction of the displacement of any point and the axis perpendicular to the surface of the slope is represented by an equation. — V. S. N.

- 184-364. Nobles, Laurence H. Glaciological investigations, Nunatarssuaq ice ramp, northwestern Greenland: U.S. Army Snow, Ice and Permafrost Research Estab., Tech. Rept. 66, 57 p., 1960.

The Nunatarssuaq ice ramp is a gently sloping ice mass approximately 4 miles long by 2 miles wide that forms part of the margin of the ice cap in northwest Greenland 30 miles northeast of Thule. The ice of the ramp is of subpolar type in which negative temperatures prevail throughout most of the year in all but the upper few feet; the temperature regime is analogous to that of perennially frozen ground. Comparison between the total amount of ice ablated from the lower ramp and the amount delivered to the ramp by flow through the gap south of Nuna Knob indicates a strongly negative budget balance for the ramp during the period studied.

Velocity of ice movement on the ramp is 1-2 in. per day. The angle of the movement vector never differs from the horizontal by more than 5°. Calculations of the amount of movement of ice toward the surface to replace that

lost by ablation also indicate a strongly negative budget balance and suggest complete decay of the ramp in 300-600 yr under present climatic conditions.

Deformation of the ice during flow has formed metamorphic structures of both tensional and shear origin including foliation, blue bands up to 20 feet thick, amber bands consisting of unequally-distributed finely-divided debris, joints, small crevasses, and ice dikes. — V. S. N.

- 184-365. Lliboutry, Louis. Mesure des mouvements d'un névé par prospection magnétique [Measurement of the movements of a névé by magnetic surveying]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4415-4416, 1960; also in Jour. Glaciology, v. 3, no. 29, p. 879-881, 1961.

The settling and movement of névé can be followed with the aid of magnetized steel pipes sunk in vertical holes; the subsequent location and attitude of these pipes is determined by means of a vertical magnetometer. The method was tested in the upper Vallée Blanche, at the foot of the Aiguille du Midi laboratory, where net winter accumulation of snow is of the order of 4 or 5 m, most of which melts during the summer. — D. B. V.

- 184-366. Cornet, André. Déplacement du glacier de l'Astrolabe et bilan de masse en Terre Adélie [Displacement of the Astrolabe glacier and mass balance in Adélie Land]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 3, p. 404-406, 1960.

Ice velocities measured on the Astrolabe glacier in Antarctica in 1958-59 ranged from 90 to 150 cm per day from point to point. There was no appreciable seasonal variation. Assuming that velocity is constant with depth and allowing for surface and subglacial melting, it is calculated that the ice flow along the coast is of the order of 20,000 tons per meter per year. The measured accumulation is in excess of the flow. In spite of this excess, however, the coastal ice has been receding at a rate of 3 km per century since the discovery of Adélie Land in 1840. The ablation rate of 40 cm of ice per year is sufficient to explain the retreat. — D. B. V.

GRAVITY

- 184-367. Roy, Amalendu. On some properties of residuals and derivatives: Jour. Geophys. Research, v. 66, no. 2, p. 543-548, 1961.

It is demonstrated (1) that the n th vertical derivative of a gravity or magnetic field is equal to $2^n g k^n$, where k is the mean curvature of the equipotential surfaces and g is the value of gravity (or vertical component of magnetic field), and (2) that the grid residuals are identical in their properties with those of the second-derivative maps, except for a constant factor, and are, therefore, superfluous and sometimes misleading. — Author's abstract

- 184-368. Wertheim, Gunther K. The Mössbauer effect: a tool for science: Nucleonics, v. 19, no. 1, p. 52-57, 1961.

The concept has long been held that any atom that emits a gamma photon must recoil so that momentum is conserved. It has now been demonstrated, however, that if the emitting atom is bound in a solid, it can be the solid as a whole that recoils rather than the individual atom. Since momentum is conserved, the energy taken up by the crystal is in the ratio of the mass of the photon to twice the mass of the crystal. When the uncertainty of recoil energy is removed from gamma emission and absorption, gamma-ray line widths be-

come so narrow as to make possible many experiments undreamed of a few years ago. For example, the energy shift has been measured for a proton moving from a point of greater gravitational potential to one of lower potential—all within the same physics laboratory. — J. W. C.

- 184-369. Morelli, C[arlo]. Special Study Group No. 5, general report: Bull. Géod., no. 51, p. 7-43, 1959.

This report of Special Study Group No. 5 (absolute determinations of gravity) of the International Association of Geodesy compiles information concerning the definition and corrections to the Potsdam Gravity System, new absolute determinations in various parts of the world, a world calibration standard, connections between absolute stations and first-order network stations, and the international gravity formula. — D. B. V.

- 184-370. Reichender, Karl. Reference-value of gravity at Potsdam: Bull. Géod., no. 51, p. 80-81, 1959.

Absolute gravity determinations since 1900 show that the Potsdam reference value is too high by at least 10 mgal, but values obtained to date are insufficient to determine this difference to within about 1 mgal. Until the numerous new absolute determinations recommended by the International Gravity Commission in 1956 are completed in Europe and America, it is premature to establish a definitive correction to the Potsdam reference value. A variation of 10 mgal in this value causes a variation of 10^{-5} in any values dependent on the acceleration of gravity. — D. B. V.

- 184-371. Rieckmann, E., and German, S. Untersuchungen und Vorschläge zur Definition des Potsdamer Schweresystems und zu seiner Übertragung [Investigations and proposals concerning the definition of the Potsdam Gravity System and its transference]: Bull. Géod., no. 51, p. 44-49, 1959.

Examination of the problem of the definition of the Potsdam reference system shows that many uncertainties must be eliminated before the present system is changed. This report discusses the following points: the position, and especially the height, of the Potsdam, Teddington, and Washington reference points; the transference of the Potsdam reference point to the auxiliary points in the Potsdam Geodetic Institute; transference of these auxiliary points to Bad Harzburg, Teddington, Washington, and other absolute gravity points; the effect of gravity tides on measurements with reversible pendulums; and the deviation of the time used by Kühnen and Furtwängler in their 1960 measurements from Ephemerides time.

It is concluded that the height of the Potsdam reference point can be calculated from the data of Kühnen and Furtwängler, and that previously accepted gravity differences between Potsdam and the auxiliary points in the Potsdam Geodetic Institute must be corrected, preferable by gravimeter measurements. — D. B. V.

- 184-372. Reichender, K. Stellungnahme zu dem Manuskript E. Rieckmann und S. German (Untersuchungen und Vorschläge zur Definition des Potsdamer Schweresystems und zu seiner Übertragung) [Opinion on the manuscript of E. Rieckmann and S. German (Investigations and proposals concerning the definition of the Potsdam Gravity System and its transference)]: Bull. Géod., no. 51, p. 104-106, 1959.

The importance of knowing the correct height of a gravity reference station is emphasized. Reichender objects to the proposal of Rieckmann and German (see Geophys. Abs. 184-371) for using the reference height 86.24 m (based on Kühnen and Furtwängler's 1906 formula) for international purposes, as this formula has led to the erroneous Potsdam gravity value. Gravity tides and the difference from Ephemerides time must also be taken into account. A preliminary value of $g=981,275.3$ mgal is given for measurements made in the cellar of the Potsdam Geodetic Institute. — D. B. V.

- 184-373. Baranov, Vladimir [I.]. Gravit  normale   l'ext rieur de la Terre [Normal gravity outside the earth]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 15, p. 1546-1548, 1960.

A formula is derived in finite terms for normal gravity prolonged above the earth's surface, using spheroidal coordinates. — D. B. V

- 184-374. Smith, R. A. Some formulae for interpreting local gravity anomalies: Geophys. Prosp., v. 8, no. 4, p. 607-613, 1960.

Let Oxyz be a system of rectangular axes with origin at the earth's surface and with the z axis pointing vertically downwards. If a body B lies wholly between the planes $z=h$, $z=l$ then for all x, y and for $n=1, 2, 3$ it is proved that

$$|D_n(x, y, d)| < K \rho d [J_n(\alpha) - J_n(\beta)]$$

where $\alpha=h/d$, $\beta=l/d$ and K is the gravitational constant. D_n are very easily computed from the Bouguer anomaly and J_n are tabulated in this paper. — Author's abstract

- Borisov, A. A. Gravity anomalies of mountain regions. See Geophys. Abs. 184-350.

- 184-375. Heiskanen, W. A. Assembly of gravity data: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Repts., no. 11, 59 p., 1959.

The methods of reduction, analysis, and computation of data used in the Columbus world geodetic project have been described in earlier reports; this report deals mainly with the theoretical studies, practical procedures, and results obtained during the report period (1957-59). Maps showing the available gravity material, the status of the isostatic reduction, and the mean free-air anomalies of $5^\circ \times 5^\circ$ squares are included. Three graphs illustrate the development of the free-air gravity anomalies in spherical harmonics (Legendrians) to the 8th degree for flattening values of 1/297.0 and 1/298.3. The most important problems facing the project at present are summarized at the end. A bibliography of 85 items is given. — D. B. V.

- 184-376. Visarion, Marius. Contribu ii la determinarea gradientului vertical al gravita iei cu gravimetrul static [Contribution to the determination of the vertical gravity gradient with a static gravimeter (with Russian and French summaries)]: Acad. Rom ne Studii  i Cercet ri de Geologie, v. 5, no. 2, p. 383-399, 1960.

As a result of differential determinations of the vertical gravity gradient at different levels on a vertical line at several stations in northern Transylvania under different geologic conditions, several conclusions were drawn. A N rsgaard gravimeter is accurate to $\pm 50 \times 10^{-9}$ cgs units for differences in elevation of 20 m. The effect of the housing of the instrument is insignificant if the

points of measurement are on an axis of symmetry. The topographic effect is great, as a result of which a method is proposed for evaluation of the reduction of the relief. The anomalies revealed range from $+375 \times 10^{-9}$ cgs units to -297×10^{-9} cgs units and depart up to 12 percent from the normal values of the vertical gradient. These anomalies are caused by density differences in the rocks close to the surface. — J. W. C.

- 184-377. Seya, Kiyosi [Kiyoshi]. A new method of analysis in gravity prospecting (running average method) II: Butsuri-Tanko, v. 12, no. 4, p. 166-177, 1959.

The application of the running average method of analysis of results in gravity prospecting to the general or two-dimensional case is discussed. The method is considered to be a residual gravity method that gives excellent results in (a) indicating anomalies, (b) eliminating regional gravity and noise, (c) simplifying interpretation of the anomaly map obtained, and (d) simplifying calculations (see also Geophys. Abs. 182-300). — V. S. N.

- 184-378. Lozano Calvo, Luis. Calculo de densidad y espesores del subsuelo en funcion de las anomalias de la gravedad [Calculation of the density and thickness of the subsoil as a function of gravity anomalies]: Rev. Geofísica, v. 18, no. 69, p. 1-17, 1959.

A new gravimetric method is proposed for determining the densities and thicknesses of horizontal strata. Instead of attributing to the subsoil between the station and the geoid a mean density with which to calculate the Bouguer correction, an anomaly is assumed that is due partly to a deficiency of the mean density, and from this the mean density is determined in relation to certain observation data. Taking these mean or apparent densities, the densities and thicknesses for horizontal layers are calculated with the assumption that Bouguer's hypothesis is right. Results are generalized in cases in which an adequately corrected isostatic compensation exists. An application of the method in north Segovia Province is described. — V. S. N.

- 184-379. Yungul, S. H. Gravity prospecting for reefs: effects of sedimentation and differential compaction: Geophysics, v. 26, no. 1, p. 45-56, 1961.

A study of case histories shows that deeply buried, "isolated" organic reefs frequently create recognizable but "mysterious" gravity anomalies, with no evident direct relation between the reef mass and the anomaly. The reef mechanism and depositional processes are such that there is a concentration of sand in the over-reef section. Investigation of densities in clay and sand mixtures, in terms of compaction and depth of burial, leads to the conclusion that sand concentration alone is capable of creating shallow positive and deep negative density contrasts sufficient to account for the major part of the gravity anomaly. The gravity effect calculated for a hypothetical reef is very much like observed anomalies. The gravity anomaly depends mainly on what has happened after the reef was buried rather than on the contrast at the reef level. — D. B. V.

- 184-380. Afanas'yev, N. L. Interpretatsiya anomalii Δg pryamym metodom [Interpretation of Δg anomalies by a direct method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1479-1484, 1960.

A discussion is presented of the approximation method for determination of an anomalous mass and the coordinates of its center of gravity by using the criteria for verifying interpretations of observed Δg of Lyapunov (see Geophys.

Abs. 164-164) and Smolitskiy (see Geophys. Abs. 164-160). Using the formulas derived by these authors for two-dimensional and three-dimensional bodies, coordinates of centers of gravity can be determined within a probable error of 3-5 percent, provided the width of the observed anomaly Δg is not less than double the width of its most intensive part. — A. J. S.

184-381. Service Hydrographique de la Marine and Compagnie Générale de Géophysique. Tidal gravity corrections for 1961: Geophys. Prosp., v. 8, supp. no. 1, 53 p., 1960.

Three tables give, for hourly intervals in 1961, the corrections to be added to observed gravity values to eliminate the disturbing effect of the sun and moon. The factor 1.2 introduced by elasticity of the earth has been incorporated in these values. The corrections are given in units of a hundredth of a mgal to the nearest half unit. The principles of calculation are explained briefly. — D. B. V.

184-382. Cook, A[lan] H[ugh]. Preparations for a new absolute determination of gravity at the National Physical Laboratory, Teddington: Bull. Géod., no. 51, p. 63-71, 1959.

The principles, advantages, and difficulties of the proposed method of determining absolute gravity at Teddington (by timing the flight of a ball projected upward and allowed to rise and fall freely under gravity) are discussed. Means of locating a ball in flight to 1μ are considered, and results of some studies given. The probable layout of the apparatus is outlined. — D. B. V.

184-383. Reichender, Karl. Method of the new measurements at Potsdam by means of the reversible pendulum: Bull. Géod., no. 51, p. 72, 1959.

The reversible pendulum has been chosen for redetermination of absolute gravity at Potsdam. Improvements in construction are described briefly. The new instrument will be portable. — D. B. V.

184-384. Kukkamäki, T. J. Two hundred metre pendulum: Bull. Géod., no. 51, p. 103, 1959.

A 220-m pendulum in a mine shaft 230 m deep is described briefly. It is to be used by the Finnish Geodetic Institute to measure absolute gravity with a total error of less than 1 mgal. — D. B. V.

184-385. Rose, John C., Haubrich, Richard A., and Woollard, G[eorge] P[rior]. A method for the measurement of absolute gravity: Bull. Géod., no. 51, p. 91-102, 1959.

This is virtually the same as the paper published in Am. Geophys. Union Trans., v. 39, no. 1, p. 27-34, 1958 (see Geophys. Abs. 172-104). — D. B. V.

184-386. Graf, A[nton]. Messungen mit dem Seegravimeter auf einer kreiselstabilisierten Plattform [Measurements with the sea gravimeter on a gyroscopically stabilized platform]: Deutsche Geod. Komm. Veröffentl., ser. A, no. 32, p. 41-45, 1959.

A theoretical study is made of the mean acceleration operating on the gravimeter mass, fixed firmly to a gyroscopically stabilized table, when the vessel rolls through an arbitrary angle. The results show that no acceleration of the gravimeter mass is produced by periodic movements of the vessel, assuming that the stabilization is perfect. — D. B. V.

- 184-387. International Geophysical Year Bulletin (No. 41). Gravity measurements on a surface ship at sea: *Am. Geophys. Union Trans.*, v. 41, no. 4, p. 701-706, 1960.

This is a condensed version of a paper by Worzel, published in the *Jour. Geophys. Research*, v. 64, no. 9, p. 1299-1315, 1959 (see *Geophys. Abs.* 178-227). —D. B. V.

- 184-388. Gantar, C., and Morelli, C[arlo]. Alcuni effetti della pressione sul comportamento dei gravimetri Worden [Some effects of pressure on the behavior of Worden gravimeters]: *Boll. Geofisica Teor. ed Appl.*, v. 1, no. 3, p. 221-228, 1959.

Four Worden gravimeters have been subjected to rapid variations of ambient pressure corresponding to elevation differences of 200 m to 4,000 m. It was found that adiabatic variations in temperature (up to 4°C) had no effect on gravimeter readings, whereas changes in pressure produced either negative or positive linear variations in the small dial readings. (See also *Geophys. Abs.* 181-267.) —A. J. S.

- 184-389. Fajkiewicz, Zbigniew. Zastosowanie automatycznych maszyn liczących w interpretacji zdjęć grawimetrycznych i magnetycznych [Application of automatic digital computers in interpretation of gravity and magnetic surveys (with English summary)]: *Przegląd. Geol.*, v. 8, no. 9, p. 459-466, 1960.

The results of application of automatic digital computers to interpretation of gravity and magnetic surveys are presented. Computers may be used in two ways: (1) partial automation using formulas in conjunction with a digital computer, or (2) full automation using computers of such type as universal, electronic, XYZ digital, or "Aritma" statistical machines. The tests showed that the computers shorten calculating time 4-8 fold, reduce costs by 50 percent, and allow introduction of new precise methods of interpretation. —J. W. C.

- 184-390. Behrendt, J. C., and Woollard, G[eorge] P[rrior]. An evaluation of the gravity control network in North America: *Geophysics*, v. 26, no. 1, p. 57-76, 1961.

Observations with a LaCoste and Romberg geodetic gravimeter having a very low nearly linear drift rate, a high reading precision, and a worldwide range were made at about 300 sites in order to check and extend the gravity control network in North America. The instrument was calibrated against the North American standardization range of pendulum measurements from Paso de Cortes, Mexico, to Fairbanks, Alaska. A statistical evaluation of the precision of the network based on reoccupations of 40 major control stations gives an estimated standard deviation of 0.08 mgal. Values for the 40 reoccupied stations of the airport network established in 1958 (see *Geophys. Abs.* 174-212), adjusted for the difference in calibration standard used, agree on the average to within 0.2 mgal with the results of this study. Reoccupations of old pendulum stations suggest that much of that network is in error by more than 3 mgal. Tables give descriptions of sites occupied and principal facts for position, elevation, observed gravity, and free-air and Bouguer anomalies. —D. B. V.

- 184-391. Preston-Thomas, H., Turnbull, L. G., Green, E., Dauphinee, T. M., and Kalra, S. N. An absolute measurement of the acceleration due to gravity at Ottawa: *Canadian Jour. Physics*, v. 38, no. 61, p. 824-852, 1960.

An apparatus for determining the absolute value of gravity by measuring the distances through which a rule falls in discrete time intervals is described. From the data associated with 64 drops with two nonmagnetic stainless steel rules in vacuum, a value of g at the absolute gravity station at Ottawa of $980.6132 \text{ cm per sec}^2$ with a possible error of $\pm 0.0015 \text{ cm per sec}^2$ has been obtained. This value is $13.7 \pm 2.0 \text{ mgal}$ less than the Potsdam value at that position. — Authors' abstract

- 184-392. Preston-Thomas, H. Absolute determination of g at Ottawa: *Bull. Géod.*, no. 51, p. 107-111, 1959.

The falling bar method used to determine absolute gravity at Ottawa is described briefly. A series of 19 drops gave a mean value of $g = 980.6134 \text{ cm per sec}^{-2}$ with an average deviation of 1.65 mgal . The local Potsdam value is $980.6293 \text{ cm per sec}^{-2}$. — D. B. V.

- 184-393. Winter, P. J., and Valliant, H. D. Relative gravity determinations in the Prairie Provinces with Dominion Observatory bronze pendulum apparatus: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 141-154, 1960.

Gravity values were determined at five locations in western Canada during 1958, using the bronze pendulum apparatus of the Dominion Observatory. Results, referred to the adopted value of $980.62200 \text{ cm per sec}^2$ for the National Reference Station, are as follows: Winnipeg— 980.9963 ; La Ronge— 981.3949 ; Saskatoon— 981.1356 ; Estevan— 980.8598 ; and Regina— 980.9588 .

The standard deviations obtained are due chiefly to drifts of up to 3 parts in 10^7 in the frequency standard and to errors of 1 or 2 parts in 10^7 which arise during the scaling of the photographic records. Errors due to temperature and pressure and to variations in arc are believed to be negligible. The spreads in determinations of pendulum periods are at least comparable to results obtained by other observers in recent years. — D. B. V.

- 184-394. Innes, M. J. S. Gravity connexions for Canada: *Bull. Géod.*, no. 51, p. 73-79, 1959.

Gravity ties completed by the Dominion Observatory are listed. These together with recent transatlantic connections and ties within the European gravimeter network should provide a firm basis for appraising the consistency of North American (Ottawa and Washington, D. C.) and European absolute determinations. — D. B. V.

- 184-395. Baglietto, Eduardo E. Gravedad absoluta en Buenos Aires [Absolute gravity in Buenos Aires]: *Bull. Géod.*, no. 51, p. 52-62, 1960.

Details of pendulum measurements of absolute gravity in Buenos Aires, Argentina, made in 1954-57, are reported. The provisional result is $g = 979.696 \text{ gals}$. — D. B. V.

- 184-396. Rieckmann, E. Bericht über den Stand der Schweremessungen in Braunschweig [Report on the state of gravity measurements at Braunschweig]: *Bull. Géod.*, no. 51, p. 50-51, 1959.

This is a brief progress report on absolute gravity measurements by the falling rod method at Braunschweig, Germany. First results are expected in a few months. — D. B. V.

- 184-397. Agaletsky, P. N., Yeforov, K. N., and Martsinyak, A. I. Results of absolute determinations of the acceleration due to gravity by three independent methods in the point "VNIIM" (Leningrad): *Bull. Géod.*, no. 51, p. 82-90, 1959.

The results of determinations of the absolute value of gravity in Leningrad by three different methods are as follows (in 10^{-3} cm per sec²): by three reversible quartz pendulums of equal mass but different length, $g=981,918.7 \pm 0.4$; by free and non-free fall method, $981,921.5 \pm 1.6$; and by a falling rod in a vacuum, $981,923.3 \pm 2.2$. In the Potsdam system the value for this point is $g=981,930.8 \pm 0.6$. — D. B. V.

- 184-398. Medvedev, V. Ya., and Stepanov, P. P. Plotnochnaya kharakteristika drevnikh tolshch zapadnoy chasti Tyan'-Shanya [Density characteristic of ancient units of the west part of the Tien Shan (with English abstract)]: *Sovetskaya Geologiya*, no. 10, p. 81-98, 1960.

The geology of the western Tien Shan is examined in connection with problems of the density of the rocks that make up the older geologic units. The study is based on density determinations made on 3,000 specimens taken from outcrops; these data are tabulated. The average density of the basement rocks of the Kirgiz zone is 2.73, and for the Talass and Chatkal-Naryn zones, it is 2.70. — J. W. C.

- 184-399. Kane, M[artin] F., and Pakiser, L[ouis] C. Geophysical study of subsurface structure in southern Owens Valley, California: *Geophysics*, v. 26, no. 1, p. 12-26, 1961.

Gravity and seismic measurements in southern Owens Valley, Calif., have outlined a deep subsurface trough, bounded throughout the greater part of its length by steep faults. Depths to the bedrock floor along the central part of the valley range from 3,000 to 9,000 feet below the surface. The subsurface trough is divided into two parts, a narrow channel-like depression near Lone Pine bounded by northwest-trending faults, and a broad basin at Owens Lake bounded by a more complex series of border faults. The bedrock ridge that crops out to form Alabama Hills is shown to extend from Independence to the north edge of Owens Lake, nearly twice its visible extent. The main direction of faults that have formed the valley is northwest; subsidiary faults trend north, northeast, and east. A fairly sharp velocity boundary within the Cenozoic valley deposits suggests a change in the rate and character of deposition which was probably the result of renewed uplift in the nearby mountains. — Authors' abstract

- 184-400. Mabey, Don R. Gravity survey of the western Mojave Desert, California: U.S. Geol. Survey Prof. Paper 316-D, p. 51-72, 1960.

In the western Mojave Desert gravity exploration is an effective method of obtaining subsurface information in areas where the Quaternary sediments cover most of the underlying geology. The results of a gravity survey conducted over this area and consisting of 1,900 gravity stations are discussed; data are reduced to the complete Bouguer anomaly and presented on a contour map along with the generalized geology.

The gravity anomaly map indicates the areas in which the basement complex is overlain by Cenozoic deposits and also the order of magnitude of depth to the basement. Two-dimensional theoretical analyses are presented to show distribution of Cenozoic deposits along profiles across seven major gravity lows. Gravity anomalies are associated with several major faults; they generally exhibit a parallel trend. — V. S. N.

- 184-401. Bott, M[artin] H[arold] P[hillips], and Masson-Smith, D[avid]. A gravity survey of the Criffel granodiorite and the New Red Sandstone deposits near Dumfries: *Yorkshire Geol. Soc. Proc.*, v. 32, pt. 3, no. 13, p. 317-332, 1960.

The gravity results are presented for an area of nearly 4,000 sq mi of south Scotland along the north shores of the Solway Firth. The pattern of relatively low gravity anomalies observed over the Criffel granodiorite indicates a batholith probably reaching more than 7 miles in depth and with a major gradational increase of density toward the southeast margin. The mass deficiency represented by the granite is of the same magnitude as the additional surface load of the corresponding high ground, suggesting an isostatic balance between the two. Negative anomalies (15 mgal) are associated with the New Red Sandstone deposits at Dumfries and Lochmaben and suggest thicknesses of 3,500 feet for both basins; the shapes are best explained by contemporaneous sinking and filling. As the Irish Sea is approached, a regional increase of gravity anomalies that does not correlate with surface structure is observed. The cause may lie within the upper crust. — V. S. N.

- 184-402. Kneissl, M[ax], and Marzahn, K[urt]. Das deutsche Schweregrundnetz. Pendelmessungen 1958 [The German gravity base network. Pendulum measurements in 1958]: *Deutsche Geod. Komm. Veröfentl.*, ser. B, no. 23, pt. 7, 38 p., 1960.

The results of pendulum measurements made in 1958 along two routes in Europe are presented.

The apparatus, procedure, and reductions are described briefly; then the data are presented in tables and graphs, which constitute the greater part of the paper. — D. B. V.

- 184-403. Gloden, A[lbert]. Nouvelles mesures gravimétriques au Grand-Duché de Luxembourg [New gravimetric measurements in the Grand Duchy of Luxembourg]: *Ciel et Terre*, v. 75, no. 11/12, p. 359-360, 1959.

Calculation of free-air and Bouguer anomalies at the 96 gravimetric stations in Luxembourg revealed irregularities that necessitated remeasurement of two stations, at Borne and Sinnigen. These and 5 control stations were remeasured and compared with the results obtained in 1948; agreement was good in the control stations. Calculation of the anomalies for the two stations in question, using the new values, completes the gravimetric survey of Luxembourg. (See also *Geophys. Abs.* 158-22, 165-203.) — D. B. V.

- 184-404. Gerke, Karl, and Waterman, Heinz. Die Karte der mittleren Freiluftanomalien für Gradabteilungen 6'X10' von Westdeutschland [The map of mean free-air anomalies for 6'X10' geographic sections of West Germany]: *Deutsche Geod. Komm. Veröfentl.*, ser. B, no. 46, pt. 2, 15 p., 1959.

A map showing mean free-air gravity anomalies for each 6'X10' section of West Germany is presented; its scale is 1:1,000,000. The map is based on measurements performed in the course of preparation of the Bouguer anomaly map of Germany. For each section of the topographic map, the free-air anomaly is given as a function of station elevation. — D. B. V.

- 184-405. Gantar, C., and Morelli, C[arlo]. Revisione critica delle misure effettuate con gravimetri Worden dal 1951 al 1959 [A critical revision of relative measurements from 1951 to 1959 with Worden

gravimeters (with English abstract)): Boll. Geofisica Teor, ed Appl., v. 1, no. 3, p. 181-220, 1959.

Measurements of relative gravity carried out by the Experimental Geophysical Observatory of Trieste with the aid of Worden gravimeters are reworked in order to account for the recently discovered time and temperature variations in the gravimeters' performance. Large dial measurements have been corrected for the total nonlinearity range of response. The gravity differences so obtained are expressed in the Italian conventional calibration standard (Bologna to Ferrara, $\Delta g = +161.06$ mgal; Morelli, 1952). — A. J. S.

Marchetti, M. P. The occurrence of slide and flowage materials (olistostromes) in the Tertiary series of Sicily. See Geophys. Abs. 184-554.

184-406. Visarion, Marius, and Andrei, Justin. Noi date geofizice asupra zonei centrale a depresiunii Hațeg [New geophysical data on the central zone of the Hațeg depression (with Russian and French summaries): Acad. Române Studii și Cercetări de Geologie, v. 5, no. 1, p. 197-210, 1960.

The results are presented of gravity and magnetic surveys made in 1956-57 in the central zone of the Hațeg depression. The gravity map shows three anomaly zones: a minimum reflecting subsidence along the line Hațeg-Sarmizegethus, a maximum due to a projection of the basement in the Ciopea-Valea Dîljii anticline, and a minimum corresponding to the Pui basin. A magnetic maximum and minimum were determined. The maximum is not due to a body in the basement but to tuffs in the sedimentary section. The minimum is due to proximity to the surface of weakly magnetized schists in the Ciopea-Valea Dîljii anticline. — J. W. C.

Bumasov, A. P. The magnetic and gravitational field of the Baikal in relation to its seismicity. See Geophys. Abs. 184-157.

184-407. Rouillon, Gaston. Variations de la pesanteur dans la région de Pointe Géologie en Terre Adélie [Variations of gravity in the Point Geology region in Adélie Land]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 4, p. 570-572, 1960.

The results of gravity surveys on rock outcrops (71 stations), on sea ice (12 stations), and on a glacier tongue (5 stations) in central Adélie Land, Antarctica, are reported. A Worden gravimeter no. 332 was used. The Bouguer anomalies suggest the presence of a vast subglacial fjord. — D. B. V.

184-408. Rouillon, Gaston. Anomalies de pesanteur et profile de la calotte glaciaire antarctique en Terre Adélie [Gravity anomalies and profile of the Antarctic icecap in Adélie Land]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 5, p. 762-764, 1960.

Gravity values on the Antarctic icecap were determined at 128 stations along a 520-km traverse southward from the Dumont d'Urville station in Adélie Land. Bouguer anomalies, calculated with the aid of information from 28 seismic soundings, show a mass deficit for this region and provide a detailed profile that confirms the free air anomalies. The effect of bedrock irregularities on ice flow is revealed in the profile. — D. B. V.

184-409. Harada, Yoshimichi; Suzuki, Hiromiti; Kakinuma, Seiichi; and Yoshida, Arai. Report on the gravity measurement by the Japanese Antarctic Research Expedition, 1958-59 (in Japanese with English abstract): Antarctic Rec., no. 9, p. 43-51, 1960.

During the 3d Japanese Antarctic Research Expedition, 1958-59, only gravimeter observations were made. A Worden gravimeter used for the measurements had a small but stable drift as confirmed by continuous readings and close observations at Singapore and Capetown during both the 2d and 3d Antarctic expeditions (see *Geophys. Abs.* 177-219). The final gravity value at Syowa station, lat 69°00.4'S., long 39°35.4 E., elevation 29.2 m, is 982.540, relative to an absolute value at Capetown of 979.6470.

Observations were also made in East and West Ongul Islands, where 5 stations were established, and on the closed pack ice in Lützow-Holm Bay. These values are summarized in tables. The values of the gravity anomaly in Lützow-Holm Bay are more than +50 mgals, far exceeding the estimated error, whereas those at Syowa station are all negative. It is concluded from this that a large gravity gradient exists along the coast of Lützow-Holm Bay. — V. S. N.

- 184-410. Pratt, J. G. D. A gravity traverse of Antarctica: Trans-Antarctic Exped., 1955-58, *Sci. Repts.*, no. 2, 22 p., 1960.

The raw data are presented for a gravity traverse across the Antarctic from Shackleton to Scott Base. No interpretation can be made until reliable heights above sea level are available. Part 1 discusses the Worden gravimeter no. 14 that was used in the Antarctic work. The testing program carried out on the instrument in England is described, and all resulting data on instrumental drift summarized. Part 2 describes the journey across Antarctica, discusses instrumental drift, and presents the raw gravity values. Part 3 describes the use of the gravimeter to measure motion on the pack ice and ice shelves. The method is applicable for quick mapping of areas that are a-ground near the edge of an ice shelf. — V. S. N.

HEAT AND HEAT FLOW

- 184-411. Okai, Bin. A perturbation method for thermal convection problem (pts. 1 and 2) [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 1, p. 9-36, 1960.

In part 1, a perturbation method is presented to determine the form and amplitude of a convection which occurs in a regular cellular pattern for the values of the Rayleigh number in excess of a critical value when a layer of fluid is heated uniformly from below. The essential point is to expand the velocity and temperature functions describing the field in a power series of a parameter ϵ , while the Rayleigh number is put as a product of its critical value times $(1+\epsilon^2)$. The set of inhomogeneous equations obtained can be solved by the perturbation method used in nonlinear oscillation problems. In the two-dimensional case the slope of the heat transport curve steepens abruptly at the critical Rayleigh number. A study of convection in a sphere is presented as another example.

In part 2, the method is extended to a problem with inhomogeneous boundary conditions, that is, to the problem of steady thermal convection in a two-dimensional fluid layer heated uniformly from below under the simultaneous constraint of nonuniform temperature on its upper surface. It was found that the site of spontaneous convection cells is decided according to the surface temperature disturbance having the critical wavelength. Surface disturbances having much larger or smaller wavelength play little part in this but those having wavelengths close to the critical one are effective in determining the general feature of fluid motion. — V. S. N.

- 184-412. Kangos, James D. A preliminary investigation of the heat flux from the ocean to the atmosphere in Antarctic regions: Jour. Geophys. Research, v. 65, no. 12, p. 4007-4012, 1960.

Estimates have been made for the summer and fall seasons of the sensible and latent heat flux for 5° latitudinal zones from 40° S. to 70° S. eastward between 20° E. and 180°. Results indicate that there are large variations in the total heat flux from summer to fall and from zone to zone, the largest seasonal variations occurring in the zones 40° to 45° S. (183 cal/cm²/day) and 65° to 70° S. (187 cal/cm²/day). A minimum in the total heat flux for both summer (16 cal/cm²/day) and fall (-54 cal/cm²/day) is found in the zone 50° to 55° S., the approximate mean position of the Antarctic Convergence. Annual evaporation values were determined, revealing a minimum (15 cm) in the zone 50° to 55° S. with a secondary minimum (32 cm) along the coast. — Author's abstract

Lear, John. Canada's continent-spanning look inside earth. See Geophys. Abs. 184-438.

- 184-413. Clark, Sydney P. [Jr.]. Absorption spectra of some silicates in the visible and near infrared: Am. Mineralogist, v. 42, no. 11-12, p. 732-742, 1957.

Absorption coefficients of olivine, diopside, and three varieties of garnet were measured in the spectral range between 0.3 and 4 μ . The positions of the absorption peaks can be explained by electronic transitions between a relatively small number of excitation levels. At wave numbers between 2,000 and 7,000 cm⁻¹ the absorption coefficient of olivine is less than 0.5 cm⁻¹ and that of diopside is about 1 cm⁻¹. These results support the hypothesis that radiative heat transfer is important in the earth's mantle. — D. B. V.

- 184-414. Goldsmid, H. J., and Bowley, A. E. Thermal conduction in mica along the planes of cleavage: Nature, v. 187, no. 4740, p. 864-865, 1960.

The results of measurements of heat flow along the cleavage planes of phlogopite, a mica that is effectively uniaxial and isotropic within the layers, are reported here. The thermal conductivity was measured both directly by an absolute method and indirectly using the apparatus described by Green and Cowles. The results obtained by both methods are in good agreement. The indirect method yielded a value of 0.0190 cm² per sec for the thermal diffusivity at 27°C, leading to a thermal conductance of 0.0163±0.0009 W. per °C for a rectangular block 1 cm long with a mass of 1 g. By the direct method this quantity was found to be 0.0185±0.0018 W. per °C, with no significant variation over the temperature range -85°C to 35°C. Assuming a density of 2.8 g per cm³, the values of thermal conductivity corresponding to these conductance values are 0.046 and 0.052 W. per cm per °C, respectively. It is concluded that the thermal conductivity of phlogopite along the cleavage planes is an order of magnitude greater than in the perpendicular direction. — D. B. V.

- 184-415. Somerton, W[ilbur] H., and Boozer, G. D. Thermal characteristics of porous rocks at elevated temperatures: Jour. Petroleum Technology, v. 12, no. 6, p. 77-81, 1960.

Thermal diffusivities of several sedimentary rocks were measured by a rapid unsteady-state technique for the temperature range 200° F-1,800° F. These data are compared with steady-state conductivity measurements, and agreement between the two methods is satisfactory. Thermal diffusivity de-

creases markedly with increased temperature. The reliability of the thermal values decreases at higher temperatures; the reported values of diffusivity and conductivity may be up to 20 percent too high at temperatures in excess of 1,500°F. — J. W. C.

- 184-416. Joyner, William B. Heat flow in Pennsylvania and West Virginia: *Geophysics*, v. 25, no. 6, p. 1229-1241, 1960.

In order to obtain heat-flow values for six wells in Pennsylvania and West Virginia a simple technique was developed for estimating thermal resistivities from well-sample logs. This technique made use of average resistivity values for various categories of sedimentary rocks. The averages were calculated from available resistivity measurements on rock specimens, many of which did not come from the region in which the wells were located. The results indicate that, allowing for error in the estimates, the heat flow at the wells lies between 1.1 and 1.5 microcal per cm² sec. The problem of developing a more accurate technique for estimating resistivity is discussed. Such a technique would be valuable in extending our knowledge of the earth's heat flow. — Author's abstract

- 184-417. Jaeger, J. C. The effect of drilling fluid on temperatures measured in bore holes: *Jour. Geophys. Research*, v. 66, no. 2, p. 563-569, 1961.

A series of measurements of water temperature and flow were made during diamond drilling of a hole, and a few temperature logs were taken. In this particular case it was found unnecessary at any time to wait more than a day after drilling ceased to determine the geothermal gradient to within 5 percent. This is because the drilling system acts as a heat exchanger. For the relatively small circulation of water used in diamond drilling, heat exchange takes place in restricted regions at the top and bottom of the hole. Therefore, unless very large quantities of water are circulated, the temperature gradient near the center of the hole is little affected. In rotary drilling, on the other hand, in which very high fluid velocities are used, the temperature in the hole is determined almost entirely by the input temperature of the fluids. Methods of correcting observed temperatures for the effects of drilling fluid are discussed. — D. B. V.

- 184-418. Cheremenskiy, G. A. O zone narusheniya teplovogo sostoyaniya gornyx porod bureniyem skvazhiny [On the zone of disturbance of the thermal state of rocks by drilling of a borehole]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1507-1509, 1960.

Disturbance of the thermal equilibrium in the rock surrounding a borehole is governed by the duration of the drilling, the temperature of the drilling mud, the thermal properties of the rock, and the geologic and hydrologic features of the region. The radius of this disturbance may reach 10-20 m or more. — A. J. S.

- 184-419. Ovnanatov, S. T., and Tamrazyan, G. P. O termicheskikh usloviyakh antiklinal'noy zony Surakhany-Karachukhur-Zykh-Peschanny (Apsheronskiy poluostrov) [Thermal conditions of the Surakhany-Karachukhur-Zykh-Peschanny anticlinal zone (Apsheron Peninsula) (with English abstract)]: *Sovetskaya Geologiya*, no. 10, p. 99-111, 1960.

Results are presented of geothermal investigations in one of the most important anticlinal zones of the Apsheron Peninsula. A total of 2,321 measurements were made in 286 boreholes, most of which were shut-down and therefore in thermal equilibrium. Maps and a cross-section show a definite correlation between the structure of the anticline and a geothermal anomaly. The geothermal step at shallow depths (200-500 m) is 20-30 m per °C, whereas it increases to 40-80 m per °C at depths of 1-4 km. — J. W. C.

- 184-420. Ananyan, A. L. Podzemnoye teplo rayona Dzhermuk i problema osvoyeniya yego prirodnykh goryachikh vod [Subsurface heat of the Dzhermuk region and the problem of utilization of natural hot waters (with English abstract)]: Sovetskaya Geologiya, no. 12, p. 98-105, 1960.

The upper Senonian limestones of the Armenian S. S. R. are strongly fractured and constitute excellent aquifers. Within the Daralagyz basin in the vicinity of Dzhermuk the water in the aquifers has an anomalously high temperature, which is attributed to igneous activity in the region. The geothermal step in the depth interval 10-100 m is 4-5 m per °C; below this depth the rise is less rapid. These thermal waters can possibly be used in heating of buildings. — J. W. C.

INTERNAL CONSTITUTION OF THE EARTH

- 184-421. MacDonald, Gordon J. F. Chondrites and the chemical composition of the earth, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 476-494, 1959.

The present rate of heat loss from the earth is consistent with the hypothesis that a major portion of the earth is composed of chondritic material. The observed ratio of iron to stony meteorites and the abundance of iron in the sun favor an earth consisting wholly of chondritic material. If this is true, then the earth's core probably contains major amounts of silicon alloyed with iron; this type of core is consistent with seismic data interpreted in terms of high-pressure equations of state. On the chondritic model the mantle must be chemically differentiated with heat-producing elements within the upper 600-700 km. A material intermediate in chemical composition between dunite and basalt is thus suggested for the upper mantle under the oceans. A similar but less stringent requirement on the composition of the mantle, independent of the chondritic hypothesis, is set by its solid nature. — V. S. N.

- 184-422. Clark, Sydney P., Jr. Equations of state and polymorphism at high pressures, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 495-511, 1959.

A qualitative and general discussion of phase changes and equations of state is given. Theoretical and experimental results from the field of high-pressure physics lead to generalizations that can be applied to the earth. Reviews of Thomas-Fermi theory and of the present status of quantum-mechanical equations of state of simple substances are included. The results of studies of equations of state and polymorphism can be related to the earth through seismic velocities. The ratio of bulk modulus to density (elastic ratio) at various depths in the earth is known from velocities of elastic waves; it can be obtained also from the equation of state, and comparison of these two sets of data yields the most important body of information about the internal constitution of the earth. Information about the homogeneity of the earth can also be derived from the elastic ratio; expected changes in this quantity with pres-

sure or depth derived from the equation of state are much less than those observed in the earth. The departures occur at the M-discontinuity and at the boundaries of the outer and inner core. Equations of state suggest that none of the discontinuities could result from compression of homogeneous material. — V. S. N.

- 184-423. Turekian, Karl K., and Wedepohl, Karl Hans. Distribution of the elements in some major units of the earth's crust: *Geol. Soc. America Bull.*, v. 72, no. 2, p. 175-192, 1961.

This paper presents a table of abundances of the elements in the various major units of the earth's lithic crust with a documentation of the sources and discussion of the choice of units and data. — Authors' abstract

- Pekeris, C. L., Alterman, Z., and Jarosch, H. Comparison of theoretical with observed values of the periods of free oscillation of the earth. See *Geophys. Abs.* 184-189.

- Choudhury, Mansur Ahmed. PKP₂ and its reflections at the inside of the earth's crust. See *Geophys. Abs.* 184-194.

- 184-424. Oliver, Jack [E.], Kovach, Robert [L.], and Dorman, James. Crustal structure of the New York-Pennsylvania area: *Jour. Geophys. Research*, v. 66, no. 1, p. 215-225, 1961.

Phase velocities of Rayleigh waves in the period range from 15 to 45 seconds were determined from seismograms of the Waynesburg, Pennsylvania-Ottawa, Ontario-Palisades, New York, tripartite array. A theoretical model, compatible with these data and with previously published seismic refraction data of Katz, consists of a low-velocity sedimentary layer overlying two crustal rock layers which in turn overlie the earth's mantle. The total crustal thickness is about 37 kilometers. Calculations of Rayleigh wave dispersion for a variety of theoretical models show that small variations in elastic properties from place to place may cause significant errors in the determination of total crustal thickness if such variations are neglected when the phase-velocity method is used independently. The error is considerably less if supplementary data are used in conjunction with phase-velocity data as was done in the example cited above. — Authors' abstract

- 184-425. Diment, W[illiam] H., Stewart, S[amuel] W., and Roller, J. C. Crustal structure from the Nevada Test Site to Kingman, Arizona, from seismic and gravity observations: *Jour. Geophys. Research*, v. 66, no. 1, p. 201-214, 1961.

The time of the first arrival of seismic waves generated by explosions at the Nevada Test Site and recorded along a 300-km line southeastward through Kingman, Arizona, is expressed as $T_0 = \Delta/5.2$, $T_1 = 0.34 + \Delta/6.15$, and $T_2 = 5.82 + \Delta/7.81$, where time is in seconds and the shot-detector distance (Δ) is in kilometers. Assuming constant velocities for the layers, the thicknesses are $H_0 = 1.7$ km, $H_1 = 26.7$ km, and $H_0 + H_1 = 28$ km (below a 1-km datum). The average Bouguer anomaly is about -120 milligals, and the average elevation is about 1.1 km. Seismograms were examined for P-waves indicating the presence of other discontinuities within and below the H_2 layer, but the separation between seismic stations was too great to establish the presence of such discontinuities. A questionable alinement of weak arrivals following the T_2 refraction time by less than 1 second may indicate the presence of a discontinuity below 28 km. Fair alinements of strong second arrivals in the range 200-400 km might be interpreted as direct P-waves or channel waves in the H_1 layer. — Authors' abstract

Adams, W[illiam] M[ansfield], Preston, R. G. , Flanders, P. L. , Sacks, D. C. , and Perret, W. R. Summary report of strong-motion measurements, underground nuclear detonations. See Geophys. Abs. 184-258.

Narans, Harry D. , Jr. , Berg, Joseph W. , Jr. , and Cook, Kenneth L. Sub-basement seismic reflections in northern Utah. See Geophys. Abs. 184-569.

184-426. Schulz, R[udolf], and Weyl, R[ichard]. Erdbeben und Krustenaufbau im nördlichen Mittelamerika [Earthquakes and crustal structure in northern Central America (with Spanish summary)]: Neues Jahrb. Geologie u. Paläontologie Monatsh., no. 5, p. 193-201, 1960; also in El Salvador Servicio Geol. Nac. Bol. Sismol., v. 5, p. 36-40, 1959.

Crustal structure in northern Central America is inferred from earthquakes registered at the seismic stations in El Salvador, which were modernized in 1954. Shocks originating in the region of the volcanic chain of El Salvador indicate a fairly homogeneous ground; focuses are shallow and are related to the fault system of the Pacific coast. A line of earthquake focuses at depths of 70-150 km lies off the Pacific coast, parallel to the shore. The region of the Middle American Trench is characterized by shallow focuses. Unusually long-period surface waves observed in this region are evidence that the trench is filled with rather thick unconsolidated sediments. The mechanism of the deeper focuses has been investigated; it is probable that low-angle overthrusting of the continental plate is responsible.

Waves originating in the Gulf of Honduras, western Guatemala, and the Caribbean Sea travel continental paths to El Salvador; this agrees with geologic observations. The interpretation of earthquakes from southern Guatemala is more difficult. — D. B. V.

184-427. Aldrich, L. T[homas], Bass, M[anuel] N. , Tuve, M[erle] A. , and Wetherill, G[eorge] W. The earth's crust. Seismic studies: Carnegie Inst. Washington Year Book 58, July 1, 1958-June 30, 1959, p. 234-236, 1959; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1958-59, 1959.

The first set of seismic recorders with electronic instrumentation that requires attention only once a week has been installed in the Andes near Arequipa, Peru. A program for further such installations, and the development of relatively portable equipment for brief periods of attended recording of explosion waves are reported. The latter equipment is for observations along the west flank of the Andes and in New Mexico, Arizona, Utah, and Wyoming to obtain definitive information on subsurface structures of the Andes and beneath the great western plateaus of the United States. Establishment of a series of unattended stations is also suggested for these observations.

Current observations on density contrasts between the crust and the mantle and the implications concerning the depth of mountain roots are discussed briefly. — V. S. N.

Ewing, J[ohn] [I.], Antoine, J. , and Ewing, M[aurice]. Geophysical measurements in the western Caribbean and in the Gulf of Mexico. See Geophys. Abs. 184-

184-428. Neprochnov, Yu. P. Glubinnoye stroyeniye zemnoy kory pod Chernym morem po seysmicheskim dannym [Deep structure of the

crust under the Black Sea according to seismic data (with English summary): Moskov. Obshch. Ispytateley Prirody Byull. Otdel Geol., v. 35, no. 4, p. 30-36, 1960.

On the basis of 10 seismic profiles of an aggregate length of 1,000 km (see Geophys. Abs. 177-363), an interpretation is presented for the crustal structure of the northern part of the Black Sea to the south of the Crimea. The crust beneath the Black Sea depression differs from a continental type by the absence of a granitic layer and from an oceanic type by the presence of a thick sedimentary section. — J. W. C.

184-429. Khalevin, N. I. Stroyeniye Urala v svete geofizicheskikh dannykh [Structure of the Urals in the light of geophysical data]: Sovetskaya Geologiya, no. 12, p. 22-32, 1960.

On the basis of gravity and magnetic data, the Ural Mountain region is divided into nine belts; these have a north-south trend parallel to that of the mountain system. Marginal to these belts are oval areas of positive gravity anomaly. The axial area of the Urals, which is characterized by positive gravity values, was formed by a pre-Hercynian orogeny. The amplitude of upwarp of the basaltic substratum here is 5-10 km, and the thickness of the granitic stratum is 8-12 km. — J. W. C.

184-430. Savarenskiy, Ye. F., Solov'yeva, O. N., and Lazareva, A. P. Dispersiya voln Releya i stroyeniye zemnoy kory na severe Evrazii i v Atlanticheskoy okeane [Rayleigh wave dispersion and crustal structure in northern Eurasia and in the Atlantic Ocean]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 10, p. 168-175, 1960.

The group velocity of Rayleigh waves has been determined for earthquakes originating in the northwestern Pacific Ocean and recorded at the Moscow and Pulkovo seismic stations. The paths traversed northern Eurasia and the North Arctic Ocean. In all cases examined the group velocity values are consistent among themselves and indicate a continental crust. The thickness of the crust is 35-40 km in general; the upper and lower layers are approximately 20-25 km and 15-18 km, respectively.

Group velocities of Rayleigh waves from earthquakes originating in the Atlantic Ocean and on the west coast of Central and South America were also examined on the basis of the Moscow and Pulkovo records and found to be consistent among themselves. They indicate a homogeneous crust about 25-30 km thick. — D. B. V.

184-431. Weizman [Veytsman], P. S., Gal'perin, E. J. [E. I.], Zwerjew, C. M. [Zverev, S. M.], Kosminskaya, J. P. [Kosminskaya, I. P.], and Krakshina [Krakshina], R. M. Seismische Untersuchungen über den Tiefenbau der Erdkruste, die in der UdSSR nach dem Plan des Internationalen Geophysikalischen Jahres durchgeführt wurden [Seismic investigations of the deep structure of the earth's crust, which were carried out in the USSR as part of the International Geophysical Year project]: Freiburger Forschungshefte C 81 Geophysik, p. 150-159, 1960.

Crustal structure in the transition zone between the Asiatic continent and the Pacific Ocean was investigated during the International Geophysical Year by several cooperating Soviet institutions, using the method of deep seismic sounding. The results, presented in the form of maps, graphs, and seismograms, and discussed here.

Three groups of waves were recognized in the seismograms: (1) P_0 , with apparent velocities $v=4-7$ km/s; (2) P_x , with $v=6-8$ km/s; and (3) P , with $v=6-10$ km/s. These are refracted along the sedimentary and granitic layers, the basaltic layer, and on the M-discontinuity, respectively. The traveltime curves were of three types. The oceanic type, with two branches corresponding to P_x and P -waves, was registered in the ocean basin east of the Kurile arc. It represents a crust that consists of basalt overlain by a thin (about 1 km) sedimentary layer, with a total thickness—including a water layer more than 5 km deep—of 12-18 km at most. The continental type, with three branches corresponding to P_0 , P_x , and P -waves, was registered in the Kuriles, on the Kamchatka coast, and in the northern part of the Sea of Okhotsk. It represents a three-layered crust that consists of sedimentary, granitic, and basaltic zones, with a thickness of 25-30 km. The intermediate type with branches corresponding to P_x and P -waves, was registered in the deep southern part of the Sea of Okhotsk and in the vicinity of the Commander Islands. It represents a crust with an undifferentiated layer overlying the basalt, with a maximum total thickness of 20 km. — D. B. V.

- 184-432. Matuzawa, Takeo; Matumoto, Tosimatsu; and Asano, Shuzo. The crustal structure as derived from observations of the second Hokoda explosion [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 2, p. 78-89, 1960.

The crustal structure of the Kwantō area and of northeast Japan as derived from observations of the second Hokoda explosion are discussed. In the Kwantō area three layers were observed above the M-discontinuity: the first layer (velocity 1.74 km/s, thickness 0.92 km) does not exist north of Hitati; the second layer (velocity 5.5 km/s, thickness 4.3 km) thins northward at a distance of 40 km from Hokoda, and near Tamura the third layer (velocity 6.2 km/s) approaches the surface. The near-surface presence of the 6.2 km/s layer is also supported by surface geology and gravity data. In northeast Japan, except in the areas of Siroiwa and Kaneyama, a thin surface layer is underlain by a 5.8 km/s second layer with a thickness of 4-8 km; it corresponds to the 5.5 km/s layers of the Kwantō area. Under Hokoda the velocity of the P_n waves is 7.7 km/s and the depth to the M-discontinuity is 27.5 km; the discontinuity rises northward at an angle of about 2° . — V. S. N.

- 184-433. Research Group for Explosion Seismology. Observations of seismic waves from the second Hokoda explosion (in Japanese with English abstract): *Zisin*, ser. 2, v. 13, no. 2, p. 90-96, 1960.

Seismic waves from the detonation of about 1 ton of explosives near Hokoda, Ibaragi Prefecture, Japan, on August 16, 1957, were observed at 18 temporary stations in Japan. The purpose of the study was to determine the crustal structure of the northern Kwantō district and of northeast Japan; moreover, the profile obtained is in reverse to that from the earlier Kamaisi explosions and can be used to verify the structure for northeast Japan derived from the earlier profile. Traveltime tables and diagrams are included. — V. S. N.

- 184-434. Nishimura, Eiichi; Kamitsuki, Akira; and Kishimoto, Yoshimichi. Some problems on Poisson's ratio in the earth's crust: *Tellus*, v. 12, no. 2, p. 236-241, 1960.

The P-S diagram was used instead of the time-distance graph to estimate the value of Poisson's ratio in the earth's crust. Applying the method to 18 earthquakes in southwestern Japan, a region of anomalously large Poisson's ratio was found in the Kyushu district at a depth of about 20-40 km; this suggests the possible existence of a local magma reservoir. The azimuthal dis-

tribution of Poisson's ratio in the crust in the case of two earthquakes (Dai-shoji-Okii and Tokushima) was found to be considerably different in the push- and pull-zones of initial motion; this may be related to the conditions of stress accumulation leading to the earthquake. — D. B. V.

Popov, I. I. On the dispersion of long-period Love waves in the continental and oceanic crust on the Indonesia-Crimea traverse. See *Geophys. Abs.* 184-197.

184-435. *Petroleum Times*. Why Guadalupe?: *Petroleum Times*, v. 65, no. 1656, p. 93, 1961.

The AMSOC Mohole Committee has proposed an experimental drilling operation in 12,000 feet of water 14 miles off Guadalupe Island in the Pacific Ocean west of Mexico. The CUSS1 drilling barge is to be used. This hole is not designed to reach the M-discontinuity but to test the feasibility of drilling from an unanchored ship. Several hundred feet of core are expected to be recovered. — J. W. C.

184-436. Magnitskiy, V. A. Projekt "Mokho" [The Moho project]: *Priroda* no. 1, p. 87-88, 1960.

The drilling of a hole into the earth's mantle is considered essential as a direct method in the study of the composition and the structure of the crust. The Moho project calls for drilling in either the Pacific Ocean (near Acapulco) or the Atlantic Ocean (near Puerto Rico). The surface drilling ship will be anchored to have a drift of not more than 2 percent of the ocean depth over the hole; pipe sections up to 1 km long are to be transported under water; and sea water is to be used for the drilling solution. — A. J. S.

184-437. Krauss, W. Die erste Durchbohrung der Sedimentschicht unter dem Ozean [The first boring through the sediment layer under the ocean]: *Umschau*, v. 60, no. 6, p. 176-177, 1960.

This is a report on the "Mohole" project for drilling through the earth's crust. (See also *Geophys. Abs.* 182-360.) — D. B. V.

184-438. Lear, John. Canada's continent-spanning look inside earth: *New York, Saturday Review*, v. 44, no. 5, p. 35-40, 1961.

As a part of the "Upper Mantle Project" of the International Union of Geodesy and Geophysics, the Dominion Observatory of Canada is establishing 27 seismic stations throughout Canada to be completed by 1963. As the heat mechanism of the earth is important also for understanding the deepest mysteries of the planet, Canada intends to drill a hole from 1,000 to 2,000 feet deep at each station and to take temperature readings at 100-ft intervals as regularly as readings will be made of the atmospheric thermometer. It is possible that this program will provide more information concerning the interior of the earth in a shorter period of time than will be provided by the Mohole project of the United States. — V. S. N.

184-439. Arnold, Kurt. Die Präzessionsbewegung der Erde und der Bahn der künstlichen Erdsatelliten, die Abplattung der Erde und die Dichtverteilung im Innern [The precessional motion of the earth and the orbit of artificial earth satellites, the flattening of the earth, and the density distribution in the interior]: *Gerlands Beitr. Geophysik*, v. 69, no. 4, p. 191-199, 1960.

Values obtained from satellite observations for the static and dynamic flattening of the earth show that the density distribution in the deep interior of the earth deviates within certain limits from hydrostatic equilibrium. — D. B. V.

- 184-440. Dauvillier, Alexandre. Sur l'état convectif interne du Globe et les phénomènes hydromagnétiques [On the internal convective state of the globe and hydromagnetic phenomena]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 15, p. 1449-1450, 1960.

The scale and velocity of thermal convections in the earth's interior are discussed. Using a value of 1.5×10^{-14} cal per g per sec for the average heat discharge of stony meteorites, a maximum velocity of 30 m per yr in the mantle is obtained, which is compatible with the duration of orogenic-magmatic cycles.

Using a value of 18×10^{-16} cal per g per sec for the heat discharge from iron meteorites, the maximum velocity of convection in the core is calculated to be 11 m per yr. This is much smaller than the amount required by dynamo theories of geomagnetism. — D. B. V.

- 184-441. Shneiderov, A[natol] J. On the temperature of the earth's mantle-core boundary: Boll. Geofisica Teor. ed Appl., v. 2, no. 8, p. 647-649, 1960.

A mantle-core boundary—the plutosphere of the earth's core—is assumed to be gaseous, and a minimum theoretical temperature of $1,800^\circ\text{K}$ derived for it from the equilibrium state between the weight of the mantle and the gaseous pressure in the plutosphere for the given density $\rho = 9.4$ g per cm^3 , and the mean atomic weight $\mu = 1.008$. The approximate temperatures for atomic weights 2, 3, and 4.7 are found to be $3,600^\circ$, $5,400^\circ$, and $8,500^\circ$, respectively. The mantle-core boundary temperatures for the same molecular weight in a contracting earth should be lower, and for the expanding earth—higher than the above given temperatures determined for a static model of the earth. A method is proposed for determining whether the earth expands or contracts. — Author's summary

Slichter, Louis B. The fundamental free mode of the earth's inner core. See Geophys. Abs. 184-190.

- 184-442. Lucke, Otto. Bemerkungen zur Dissertation von A. Vogel "Über die Unregelmässigkeiten der äusseren Begrenzung des Erdkerns (auf Grund von am Erdkern reflektierten Erdbebenwellen)" [Remarks on the dissertation by A. Vogel "On the irregularities of the outer boundary of the earth's core (on the basis of earthquake waves reflected at the core)" (with English summary)]: Zeitschr. Geophysik, v. 26, no. 1, p. 50-56, 1960.

Calculations are given to show that the depths to the core calculated by Vogel in the paper in question (see Geophys. Abs. 184-443) cannot correspond to reality. — D. B. V.

- 184-443. Vogel, Andreas. Über Unregelmässigkeiten der äusseren Begrenzung des Erdkerns auf Grund von am Erdkern reflektierten Erdbebenwellen [On irregularities of the outer boundary of the earth's core on the basis of earthquake waves reflected at the core (with English summary)]: Gerlands Beitr. Geophysik, v. 69, no. 3, p. 150-174, 1960.

The method of determining the depth to the earth's core from deviations in travel times of PcP, ScS, PcS, and ScP waves reflected from the core boundary is described. Anomalies in core depth calculated from 1948 to 1954 earthquake records are obviously correlated with the magnetic nondipole field and the gravity field of the earth. Together with variations in the rate of rotation of the earth, which seem to be related to geomagnetic secular variations, these phenomena are apparently due to dynamic processes in the core. Comparison of data from 1930 to 1936 indicates that the rate of change in the depth of the core also can be correlated with the rate of change of the magnetic field. If anomalies in the depth to the core and in the nondipole field change with time, there must be a corresponding change in the earth's gravity field. — D. B. V.

ISOTOPE GEOLOGY

184-444. Stuiver, M[inze]. Variations in radiocarbon concentration and sunspot activity: *Jour. Geophys. Research*, v. 66, no. 1, p. 273-276, 1961.

Variations in cosmic-ray intensities will produce variations in C^{14} production in the atmosphere. A comparison is made between variations in sunspot activity and fluctuation in C^{14} concentration during the past 13 centuries. Although a definite conclusion is not reached, the evidence given suggests some correspondence between sunspot activities and C^{14} concentration in the atmosphere. — Author's abstract

184-445. Hahn-Weinheimer, P. Bor- und Kohlenstoffgehalte basischer bis intermediärer metamorphite der Münchberger Gneissmasse und ihre $^{12}C/^{13}C$ -Isotopenverhältnisse [Boron and carbon content of basic to intermediate metamorphic rocks of the Münchberg gneiss massif and their C^{12}/C^{13} isotope ratios (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 13, p. 431-442, 1960.

The usefulness of boron and carbon in determining the origin of the eclogitic rocks of the Münchberg gneiss massif in northeastern Bavaria has been investigated. The boron content (in ppm) and elementary carbon (in percent) of samples of many different rock types are tabulated. It is found that the degree of metamorphism and relative age of ultrabasic rocks are reflected in boron content.

Comparison of the C^{12}/C^{13} ratios of the elementary carbon with carbonate carbon of certain samples suggests that the eclogites represent metamorphosed Precambrian graphite-bearing dolomitic-marly shales. — D. B. V.

184-446. Flesch, G. D., Svec, H. J., and Staley, H. G. The absolute abundance of the chromium isotopes in chromite: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 300-309, 1960.

The abundances of the chromium isotopes in 18 samples of chromite from countries responsible for 81 percent of chromite production in 1900-50 have been determined. The use of mixtures of separated isotopes to determine the accuracy indicates that the measurements are absolute. The natural abundances of the chromium isotopes in atoms percent are: $Cr^{50}=4.352\pm0.024$, $Cr^{52}=83.764\pm0.036$, $Cr^{53}=9.509\pm0.027$, and $Cr^{54}=2.375\pm0.018$. At the 99.7 confidence level of these measurements, no variation in the isotopic composition of the chromium was found in any of the samples.

The chemical atomic weight, computed on the basis of these abundance values and the latest accepted values for the masses of the isotopes involved, is 51.9985 ± 0.0013 . — D. B. V.

- 184-447. Surkov, Yu. A., Vorob'yev, A. A., Korolev, V. A., and Vilenskiy, V. D. Issledovaniye isotopnogo sostava urana v redkozemel'nykh mineralakh [Investigation of the isotopic composition of uranium in rare earth minerals]: Atomnaya Energiya, v. 9, no. 6, p. 477-482, 1960.

Investigation of Cm^{247} obtained from a reactor showed it to have a half life of 40 million years. The possibility of its existence in nature was therefore considered. As Cm^{247} changes into U^{235} in the course of its breakdown, an excess in the $\text{U}^{235}/\text{U}^{238}$ ratio should indicate the former presence of this nuclide. Such an excess was found in a specimen of gadolinite, which is 2 billion years old. This anomaly may reflect the presence of curium in nature. — J. W. C.

- 184-448. Botter, René, Lorius, Claude, and Nief, Guy. Sur la teneur en deutérium des précipitations en Terre de Victoria, Antarctique [On the deuterium content of precipitations in Victoria Land, Antarctic]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 4, p. 573-575, 1960.

The deuterium content of precipitation collected at ground level in Victoria Land, Antarctica, increases almost linearly with temperature of formation (estimated from radiosonde data). This relationship might be of use in meteorologic and glaciologic studies. — D. B. V.

- 184-449. Libby, W[illard] F. Tritium in hydrology and meteorology, in Researches in geochemistry: New York, John Wiley and Sons, p. 151-168, 1959.

It has been clear from the beginning of research on the tritium produced by cosmic radiation that labeled water resulting from production of tritium in higher levels of the atmosphere is of real usefulness. This paper reviews some of tritium research findings stemming from nuclear tests, including atmosphere-storage time for water; Castle bomb tritium deposition in the northern hemisphere; ground-water inventory, storage times, and water balance for the northern Mississippi Valley; surface ocean mixing rates; and regional hydrological applications. It concludes with a brief description of possible uses of synthetic tritium in studies of local hydrology. — V. S. N.

- 184-450. Bolin, B[ert]. On the use of tritium as a tracer for water in nature: Woods Hole Oceanographic Inst. Collected Repr. 1959, Contr. no. 1006, 8 p., 1960.

The interpretation of tritium data for use in deducing the ocean circulation and hydrological cycle over the American continent has become more difficult since the explosion of thermonuclear bombs beginning in 1954. Some aspects of the problem of obtaining a clear picture of naturally occurring tritium are discussed as well as some of the assumptions made by Begemann and Libby (see Geophys. Abs. 171-222) in their study of the water cycle over North America using bomb tritium as a tracer.

The microphysical processes at work in evaporation and condensation are analyzed with a discussion of the exchange of tritium between a freely-falling water drop and its environment and of the turbulent exchange of tritium in the atmosphere. Lastly, the exchange of tritium between different reservoirs in continental areas is discussed. It is concluded that the presence of moist soil is of great importance in tritium exchange over a continent; it has a shielding effect in that most of the tritium brought down by precipitation is returned to the atmosphere, and the exchange between the ground water reservoir and the atmosphere is reduced considerably. — V. S. N.

- 184-451. Slawson, William F., and Austin, Carl F. Anomalous leads from a selected geological environment in west-central New Mexico: *Nature*, v. 187, no. 4735, p. 400-401, 1960.

A detailed study of lead isotopes has been undertaken in order to evaluate variations in the isotopic composition of lead with respect to the geologic environment of the sample area. An area of about 5,000 sq mi in west central New Mexico was chosen because the number of geologic variables is at a minimum. Fresh galena was the mineral chosen for this preliminary study.

Three samples were cut from a single crystal from the wall of an open fracture zone in the Hansonburg district; the isotopic composition of a corner sample was found to be distinctly different from that of internal samples. Other samples were collected along east-west lines across north-south mineralized fractures in the Hansonburg district; a small consistent increase in radiogenic lead was found from west to east. The isotopic variations appear to reflect basement structures underlying the mineral deposits.

A plot of Pb^{207}/Pb^{204} versus Pb^{206}/Pb^{204} gives a straight line with a slope of 0.0938. The maximum age of the source of the radiogenic lead additions, calculated according to the method of Farquhar and Russell (see *Geophys. Abs.* 170-22), is $1,530 \times 10^6$ yr; this agrees fairly well with the age of $1,300-1,450 \times 10^6$ yr given by Tilton and Davis (see *Geophys. Abs.* 184-3) for the basement rocks of the southwestern United States. — D. B. V.

- 184-452. Marshall, Royal R. The amounts and isotopic compositions of lead in eclogites from the Münchberg gneiss massif (Fichtelgebirge): *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 13, p. 404-417, 1960.

The isotopic composition of lead from eclogites of the Münchberg gneiss massif in Bavaria has been determined, using the mass spectrometer and isotope dilution techniques. The concentrations of lead ranges from 0.6 to 1.6 ppm, considerable lower than in most other rocks. Two types of lead are distinguished. The first has a high Pb^{206}/Pb^{204} and low Pb^{208}/Pb^{204} ratio compared to modern average lead at the surface of the earth. A negative model age is deduced from the high Pb^{206}/Pb^{207} ratio of this lead, which therefore is anomalous in the J-type sense. It corresponds to the lead in peridotites observed by Tilton, Patterson, and Davis (1956).

The second type of lead in the eclogites is surprisingly radiogenic, but its isotopic composition lies on the zero isochron corresponding to modern lead; apparently there has been no change in the relative amounts of uranium and lead in the source for this lead for 4.5×10^9 yr. Some eclogites contain both types of lead. The eclogite lead seems to be quite different from that in most rocks. Both the amounts and isotopic compositions, however, suggest a close relation to the serpentinite of the Münchberg massif. — D. B. V.

- 184-453. Epstein, Samuel. The variations of the O^{18}/O^{16} ratio in nature and some geologic implications, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 217-239, 1959.

A few of the more recent studies of the oxygen-isotope composition of naturally occurring oxygen-containing materials are reviewed as examples of applying stable isotopes to the study of natural processes. The following are discussed: theoretical considerations including formulas for determination of the equilibrium constant K and for the fractionation factor α ; effect on α of factors other than temperature; the measurement of the O^{18}/O^{16} ratios; kinetic effects; variation of O^{18}/O^{16} ratio in natural waters; paleotemperatures by the oxygen-isotope thermometer; and the O^{18}/O^{16} ratio in minerals and rocks and in coexisting minerals. — V. S. N.

- 184-454. Ault, Wayne [U.]. Isotopic fractionation of sulfur in geochemical processes, in *Researches in geochemistry*: New York, John Wiley and Sons, p. 241-259, 1959.

Knowledge of the extent of isotopic fractionation in certain geologic processes may place limitations on the theories of origin of the crust of the earth and of ore deposits, and may aid in the study of regional geology. The stable isotopes of sulfur are important as natural tracers because of the large variations in the isotopic composition of sulfur in various phases of the lithosphere and hydrosphere. Oxidation-reduction processes, both biochemical and geochemical, are the most effective in causing sulfur isotopic fractionation; the quantitative importance of diffusion is yet to be demonstrated. Various applications of isotopic fractionation of sulfur are discussed—geologic thermometry, nature of the sulfide source in sulfide deposits, tracer experiments involving complex-ion transport, and paleoclimate. From several lines of evidence it seems that terrestrial sulfur (22.14) is heavier than meteoritic sulfur (22.21). — V. S. N.

- 184-455. Stanton, R. L. The application of sulphur isotope studies in ore genesis theory—a suggested model: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 3, p. 375-389, 1960.

In emphasizing fractionation factors, most investigators of the relationship of sulfur isotope ratios to ore genesis have made insufficient allowance for three other important factors: source variation and hybridization, migrational contamination, and homogenization not only during but also following deposition. The probable influence of these factors as well as that of fractionation during derivation, migration, and deposition on the isotopic constitution of the five classes of sulfide ore (orthomagmatic, sedimentary "normal," sedimentary "volcanic," fissure-filling, and replacement) are discussed.

A theoretical pattern of S^{32}/S^{34} ratios is deduced for the different types of ores; because of the paucity of data, this model is put forward strictly as an approximation intended to guide the systematic application of sulfur isotope studies to problems of ore genesis. Several avenues of investigation are suggested. — D. B. V.

- 184-456. Rafter, T. A., Kaplan, I. A., and Hulston, J. R. Sulphur isotopic variations in nature. Part 7—Sulphur isotopic measurements on sulphur and sulphates in New Zealand geothermal and volcanic areas: *New Zealand Jour. Sci.*, v. 3, no. 2, p. 209-218, 1960.

The average S^{32}/S^{34} ratio for 14 samples of sulfur from New Zealand geothermal areas is 22.13; this is significantly lower than the average of 22.36 found for 20 specimens from the White Island volcanic area. A smaller number of "geothermal" and "volcanic" sulfurs from New Guinea show the same trend. In 12 specimens in which sulfate and sulfur are intimately associated, wide variations in isotopic ratios are observed. An attempt has been made to correlate these variations with the biogeochemical history of the specimens (see *Geophys. Abs.* 184-457). — D. B. V.

- 184-457. Kaplan, I. A., Rafter, T. A., and Hulston, J. R. Sulphur isotopic variations in nature. Part 8—Application to some biogeochemical problems: *New Zealand Jour. Sci.*, v. 3, no. 2, p. 338-361, 1960.

Laboratory experiments with bacteria were made in an attempt to use measurements of stable sulfur isotopes to explain some biogeochemical problems. Bacterial sulfate reduction and chemosynthetic oxidation of sulfides gave en-

richment in S^{32} in laboratory experiments. Measurements of natural deposits gave conflicting results. — D. B. V.

- 184-458. Thode, H. G., Harrison, A. G., and Monster, J. Sulphur isotope fractionation in early diagenesis of recent sediments of northeast Venezuela: *Am. Assoc. Petroleum Geologists Bull.*, v. 44, no. 11, p. 1809-1817, 1960.

Data are presented for the sulfur isotope ratios in different sulfur compounds (sulfate sulfur, elemental sulfur, pyrite sulfur, organic sulfur, and sulfides soluble in hydrochloric acid) in recent marine sediments from the Pedernales oil field of northeastern Venezuela taken at depths of 20, 80, and 160 feet. All were found to be depleted in S^{34} , within a range of 10-20 permil, with respect to the original isotope ratio of sea-water sulfate. The results further indicate that bacterial reduction of marine sulfate is almost complete at depths of 12-20 feet; deeper sulfates are probably formed by oxidation of pyrite in place without further isotope fractionation.

It is suggested that over very long periods of time a partial exchange of sulfur isotopes between sulfate and pyrite in close contact takes place; this could account for the high S^{34} depletion found for pyrite and sulfate of ancient sedimentary rocks. — D. B. V.

Zähringer, J., and Gentner, W. Primordial inert gases in some stone meteorites. See *Geophys. Abs.* 184-90.

Reynolds, J[ohn] H. Rare gases in tektites. See *Geophys. Abs.* 184-114.

Murthy, V. Rama. Isotopic composition of silver in an iron meteorite. See *Geophys. Abs.* 184-99.

MAGNETIC FIELD OF THE EARTH

- 184-459. Chapman, S[ydney]. Alexandre von Humboldt et l'etude du geomagnetisme [Alexander von Humboldt and the study of geomagnetism]: *Ciel et Terre*, v. 75, no. 9/10, p. 269-284, 1959.

This is a French translation of an address given before the American Academy of Arts and Sciences in Boston in commemoration of the centenary of the death of Alexander von Humboldt in 1859, reviewing his contribution to our knowledge of terrestrial magnetism. In addition to observations of the intensity of the geomagnetic field, the magnetic equator, and short-period magnetic variations (he introduced the term "magnetic storm"), von Humboldt together with Gauss promoted the establishment of observatories for systematic study of the earth's field and its variations.

The four principal problems of geomagnetism are reviewed: the origin of the principal field, the cause of its secular variation, the regular diurnal variation, and magnetic disturbance. Worldwide magnetic observations, particularly during the International Geophysical Year, are discussed.—D. B. V.

- 184-460. Priroda. Magnetizm i zemnoye yadro [Magnetism and the earth's core]: *Priroda*, no. 6, p. 99-100, 1960.

The cause of the earth's magnetic field is discussed. The core is accepted as being fluid, electrically conductive, and carrying magnetic lines of force by means of convection currents in the fluid. Bullard's hypothesis of self-exciting dynamo mechanism in the core is discussed (see *Geophys. Abs.* 144-12525, 160-28; Kozulin 169-236). It follows from Bullard's hypothesis that there is a gradient of electric current density in the core and mantle, and that

this makes a westward drift of the variable path of the earth's general magnetic field of 0.2° per yr possible. — A. J. S.

- 184-461. Nanikawa, Tomikazu. Fluid motions in a sphere: (part 4). Thermal instability of a rotating fluid sphere heated within under a uniform magnetic field (2): Jour. Geomagnetism and Geoelectricity [Kyoto], v. 11, no. 4, p. 111-124, 1960.

A mathematical analysis is presented of the conditions under which a fluid sphere, heated from within and subjected to the simultaneous action of rotation and a uniform magnetic field, can become unstable through a marginal state of purely oscillatory motion. Contrary to the results obtained in an earlier work (see Geophys. Abs. 175-230), overstability is found to occur under both astrophysical and terrestrial conditions. — D. B. V.

- 184-462. Unterberger, R. R. Direct recording of small geomagnetic fluctuations: Jour. Geophys. Research, v. 65, no. 12, p. 4213-4216, 1960.

Several magnetometers of the alkali vapor type have been constructed, with additions, improvements, and modifications on the one pioneered by Skillman and Bender (see Geophys. Abs. 175-306). The essential parts of the new instrument are described briefly. The sensitivity of this magnetometer is 10-50 times greater than any currently available commercial magnetometer. Instruments of this type promise to open a new area of investigation into previously unknown small-amplitude magnetic phenomena. Sensitivity can be increased still further by reducing line widths, increasing available signal-to-noise ratio, or both. Line width reductions are expected from further research on spin exchange. — D. B. V.

- 184-463. Fournier, Hugo. Description des installations d'une station d'enregistrement des variations très rapides du champ magnétique terrestre [Description of the installations of a station for recording of very rapid variations of the earth's magnetic field]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 5, p. 671-673, 1960.

The Nivernais station of the Centre d'Études des Géophysique of France is equipped with induction magnetometers that have mu-metal bars. Electronic amplification of very low noise level provides very high sensitivity (of the order of 0.001γ per mm of record in the period range 0.025-0.3 sec, 0.0007γ in the 0.1-3 sec range, and about 0.0005γ in the 1-30 sec range). Calibration is effected in a very uniform auxiliary magnetic field of known amplitude and period that can be varied at will. — D. B. V.

- 184-464. Cagniard, Louis. Relation empirique approximative entre la variation séculaire magnétique et les fluctuations de la rotation terrestre [Approximate empirical relation between secular magnetic variation and fluctuations of the earth's rotation]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 10, p. 1142-1144, 1960.

The relationship between geomagnetic variations and fluctuations of the earth's rotation can be expressed approximately by the empirical formula $M_z = \alpha + \beta a + \gamma(\Delta T_m)_{a-\delta}$, where M_z is the negative component of the moment M of the field generated by a central dipole as observed at a given station; ΔT_m is the aleatory fluctuation of rotational velocity; a is the year, counting from 1900.0; and α , β , γ , and δ are constants that differ from one observatory to another. This rule seems to be valid for all usable stations in the world except Washington, D. C., which is aberrant. — D. B. V.

- 184-465. Forbush, S. E. Theoretical and statistical geophysics: Carnegie Inst. Washington Year Book 58, July 1, 1958-June 30, 1959, p. 253-256, 1959; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1958-59, 1959.

The results of investigations during the year of the equatorial electrojet and of cosmic rays are briefly reported. Preliminary studies indicate that the magnetic-disturbance diurnal variation, S_D , is sometimes augmented under the electrojet band in about the same way as the quiet-day diurnal variation, S_q , always is; however, the S_D current system does not always extend from middle latitudes all the way to the equator and thus is not always influenced by the electrojet. Observations are continuing to determine whether the semi-diurnal lunar variation, L , in horizontal intensity is enhanced under the electrojet band.

New cosmic-ray investigations included studies of the worldwide decreases in cosmic-ray intensity which accompany some magnetic storms, of the sudden decreases and recoveries in cosmic-ray intensity at the equator and at high latitude in the period from September 1956 to December 1957, and of a harmonic analysis of ionization-chamber data from Huancayo, Cheltenham, and Christchurch observatories to obtain yearly means of the 24- and 12-hourly waves of cosmic-ray intensity corrected for pressure. — V. S. N.

- 184-466. Hope, E. R. Low-latitude and high-latitude geomagnetic agitation: Jour. Geophys. Research, v. 66, no. 3, p. 747-776, 1961.

At high latitudes there are statistical morning, afternoon, and night maximums of geomagnetic agitation (irregular disturbance or activity), the complicated distribution and seasonal behavior of which can be explained only in terms of patterned corpuscular bombardment. At subequatorial latitudes there are noon, afternoon, and night maximums, of which only the last two are related to the corresponding high-latitude maximums; the noon maximum, which differs in character from the others, represents a locally generated (S_q) agitation, presumably due to direct solar radiation. Since the afternoon and night maximums are traceable continuously from auroral through middle to low latitudes, and since their respective seasonal variations are everywhere the same, they may be explained as agitation transported from high to low latitudes by an ionospheric current system resembling (and probably identical with) the S_D circulation. If so, this circulation is a physical reality, not an analytical construct; the S_D currents must flow at their own level, independently of the Dst and S_q circulations. Besides the S_D and S_q components of current-transported agitation, there is also a Dst component which, so far as identified, represents pulsative compressions of the geomagnetic field. Sudden commencements have S_D , S_q , and Dst components largely analogous to those of agitation. — Author's abstract

- 184-467. Whitham, K[enneth], Loomer, E. I., and Niblett, E. R. The latitudinal distribution of magnetic activity in Canada: Jour. Geophys. Research, v. 65, no. 12, p. 3961-3974, 1960.

Hourly ranges in the principal horizontal field component have been measured for sixteen Canadian International Geophysical Year magnetic observatories and variation stations. The latitudinal variation of disturbance measured by this index has been determined seasonally and as a function of disturbance. One station, Alert, at the northern end of Ellesmere Island, confirms the existence in these longitudes of an apparently narrow zone or area of enhanced magnetic activity, as defined by this measure of disturbance. Semi-persistent structure is also apparent in the principal auroral zone in the meridian sections of magnetic activity. Diurnal occurrence patterns, ampli-

tude-frequency plots, the diurnal variation of the mean disturbance field, and the physical significance of this range index have been investigated in an attempt to explain this apparent inner maximum of magnetic activity. More homogeneous very high latitude data are required to determine the morphology of the anomalous region found. — Authors' abstract

- 184-468. Stefant, Robert. Detection de l'activité du champ magnétique terrestre dans la bande 5-50 hz [Detection of activity of the earth's magnetic field in the 5-50 cycles per second band]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 6, p. 857-859, 1960.

A sensitive apparatus for registering rapid geomagnetic variations in the range of 5-50 cycles per second is described briefly. The records obtained with this apparatus at the Chombon-la-Forêt observatory in France on July 15, 1960, when ordinary magnetometers recorded a quiet day, show fluctuations in the 40-50 cycles per second band that have a clear diurnal variation, a rather abrupt diminution around 15 cycles per second, and a slight resumption of activity at frequencies around 5 cycles per second. These results tend to confirm the hypothesis that this activity is due to resonance of the sodium ions of the high atmosphere in the magnetic field. — D. B. V.

- 184-469. Bockel, Marc. Magnétisme terrestre à Port-aux-Français (Iles Kerguelen). Premiers résultats (1^{er} octobre 1957 au 28 février 1958) (Terrestrial magnetism at Port-aux-Français (Kerguelen Islands). First results (October 1, 1957 to February 28, 1958)): Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4417-4418, 1960.

The average geomagnetic field in the Kerguelen Islands (geomagnetic lat 56.5° S., long 127.8° E.) in January 1958, consisted of 0.18710 γ in the horizontal component and 0.44000 γ in the vertical component, with a declination of 47°38' W.

The diurnal S_q variation in the horizontal component was striking (amplitude of the order of 80-100 γ , with a maximum of 1157 in November 1957); the S_q variation in the vertical component on the other hand was feeble (average amplitude 15 γ). The amplitude of SD variation was almost the same in both components.

Diurnal magnetic activity was typical of polar regions. The frequent appearance of a characteristic magnetic bay, always related to auroral phenomena, was another feature of the magnetic field in the Kerguelens. — D. B. V.

- 184-470. MacDowall, J. Geomagnetic observations at Halley Bay: Royal Soc. [London] Proc., v. 256, no. 1285, p. 219-221, 1960.

The annual variation of geomagnetic activity is described on the basis of monthly mean K-indices for three selections of days according to activity. The difference between the diurnal variation of geomagnetic activity, as defined by K-indices, in June and December is shown to be due to a universal effect accounted for by the annual change in the diurnal variation of the angle between the earth's geomagnetic axis and the line joining the sun and earth. The observed field changes in winter (May, June, July) are interpreted as being due to a disturbing line current in the ionosphere; the diurnal variation and movement of this current are described. — Author's abstract

- 184-471. Bhattacharyya, B[ismal] K[ishna]. Correlation studies of radio-aurora, magnetic, and earth-current disturbances: Canadian Jour. Physics, v. 38, no. 5, p. 624-637, 1960.

Correlation studies have been made of the radar echo occurrence rate from aurora in half-hourly intervals at Ottawa, S and Sd components of the horizontal magnetic field H at Agincourt, and the disturbance diurnal variation of earth current at Crow River, in Canada. The diurnal variation of auroral echo occurrence rate seems to be similar to that of H. Auroral activity invariably precedes magnetic activity. The variation in the delay time between the auroral and magnetic phenomena shows a local time dependence; this variation seems to be related to the reversal of the direction of auroral ionization drift from west to east about midnight, with a subsequent change from positive to negative magnetic perturbations.

No definite conclusion could be reached concerning the relation of earth currents to the other factors; the month-to-month variation of cross-correlation coefficients were practically random. — D. B. V

Troitskaya, V. A. Pulsation of the earth's electromagnetic field with periods of 1 to 15 seconds and their connection with phenomena in the high atmosphere. See *Geophys. Abs.* 184-127.

Smith, H. W., Provazek, L. D., and Bostick, F. X., Jr. Directional properties and phase relations of the magnetotelluric fields at Austin, Texas. See *Geophys. Abs.* 184-126.

Wescott, E[ugene] M. Magnetic and telluric current disturbances in Alaska. See *Geophys. Abs.* 184-130.

Rikitake, Tsuneji. Electromagnetic induction in a hemispherical ocean by Sq. See *Geophys. Abs.* 184-133.

184-472. Bond, F. R. Motion of the aurora and magnetic bays: Australian Jour. Physics, v. 13, no. 3, p. 477-483, 1960.

Observations from the Australian Antarctic station at Macquarie Island show that the development of an auroral display is characterized by a slow northward drift, east to west longitudinal motion, and an associated positive bay in the horizontal component magnetogram in the evening hours. This is followed by a sudden change in structure of the aurora and appearance of a negative bay. The latter persists for some hours, accompanied by west to east longitudinal motion and slow southward drift of the aurora. The co-latitude of the northern limits of the aurora is strongly dependent on the level of geomagnetic disturbance. These motions are interpreted as the mass motions of electrons which constitute the magnetic bay-producing current within the boundaries of the auroral form. — D. B. V.

184-473. Cole, K. D. A dynamo theory of the aurora and magnetic disturbance: Australian Jour. Physics, v. 13, no. 3, p. 484-497, 1960.

A model of an aurora regarded as a plane slab of highly ionized air parallel to the geomagnetic field within the ionosphere is examined. The model is stable in the presence of a wind of neutral molecules which, blowing the slab across the geomagnetic field, generates an electrical polarization field perpendicular to its faces and a current along its length. This current is concentrated in a small height range and is due chiefly to electron drift. The major movements of the aurora and associated bay type magnetic disturbances can be explained by assuming an equatorward wind in the evening and a poleward wind in the night and morning hours in the equatorial vicinity of the auroral zone. It is suggested that the magnetic K and K_p indices are indicators of wind speed. The general features of magnetic disturbance current

systems within the auroral zone are considered briefly in relation to the theory, and it is suggested that auroras are visible manifestations of the current flow. — D. B. V.

- 184-474. Cole, K. D., and Bond, F. R. Criticism of the theory of magnetic bays of Bless, Gartlein, Kimball, and Sprague: *Jour. Geophys. Research*, v. 66, no. 1, p. 327, 1961.

The presence of inhomogeneities in the ionosphere (such as auroras) would cause current systems entirely different from those predicted by the theory of Bless and others (see *Geophys. Abs.* 181-358). A theory of these processes has been recently developed by Cole (see *Geophys. Abs.* 184-473) which explains in terms of a simple realistic model the observed relationship between magnetic bays and auroras and, at the same time, the typical movements of auroras and auroral ionization that correspond in fact with the movement of electrons (Bond, see *Geophys. Abs.* 184-472). The theory predicts that this movement may be at speeds greater than wind speeds by a factor of 10. — D. B. V.

- 184-475. Campbell, Wallace H., and Leinbach, H. Ionospheric absorption at times of auroral and magnetic pulsations: *Jour. Geophys. Research*, v. 66, no. 1, p. 25-34, 1961.

A study in March and April 1960 showed variations in the auroral zone ionospheric absorption of cosmic noise to be closely related to magnetic field micropulsations and short period coruscations of λ 3914. At times of polar-cap type absorption, magnetic micropulsation amplitudes were diminished. Auroral ionization in the E region, estimated from a particular luminosity-height profile, accounted for 50 percent, at least, of the cosmic noise absorption. — Authors' abstract

- 184-476. Antsilevich, M. G., and Shevnin, A. D. K voprosu o geomagnitnykh nablyudeniyakh na pervoy sovetskoy kosmicheskoy rakete [On the problem of the geomagnetic observations by the first Soviet space rocket]: *Akad. Nauk SSSR Doklady*, v. 135, no. 2, p. 298-300, 1960.

The observations made by the first Soviet space rocket on January 2, 1959 are analyzed in the light of geomagnetic conditions on that day. The results are compatible with the idea that the jump in the curve of geomagnetic field intensity versus distance from the earth (see *Geophys. Abs.* 181-346) is related to the existence of an equatorial current system connected with the occurrence of a small geomagnetic disturbance that day. — D. B. V.

- 184-477. Ziauddin, Syed. Simultaneous observations of pulsations in the geomagnetic field and in ionospheric absorption: *Canadian Jour. Physics*, v. 38, no. 12, p. 1714, 1960.

On September 20 and 21, 1960, shortly after 7 a.m. local time, regular pulsations were recorded simultaneously on the cosmic noise absorption monitor and magnetometer at Saskatoon, Saskatchewan. The magnetic pulsations had an amplitude of 30-50 gammas; those in cosmic noise absorption, 2.5-3 db. For many cycles the two phenomena remained in phase but on occasion they were exactly 180° out of phase; this occasional sudden change in phase rules out the possibility that the geomagnetic pulsations are a purely local phenomenon. Observed periods of oscillation of 2.5-3.0 minutes support the concept that the magnetic pulsations are due to toroidal hydromagnetic oscillation of the outer atmosphere (see *Geophys. Abs.* 181-372). — D. B. V.

- 184-478. Ward, Fred [Frederick W., Jr.], and Shapiro, Ralph. Influence of sunspots on geomagnetic disturbance: *Jour. Geophys. Research*, v. 66, no. 3, p. 739-746, 1961.

The hypothesis that the ejection of solar corpuscles is influenced by interactions of "active region" magnetic fields is tested empirically. The results do not support the hypothesis. — Authors' abstract

- 184-479. Hansen, Richard T. Bright 21-centimeter solar regions and geomagnetic storms in 1952-1953: *Jour. Geophys. Research*, v. 65, no. 11, p. 3827-3829, 1960.

Numerous attempts have been made to relate the nonsolar-flare-associated magnetic storms, which are most characteristic of periods of declining solar activity, to specific solar features. Results are reported here of an investigation based on solar regions producing enhanced radio flux in the decimeter range. The study discovered a marked tendency for geomagnetic storminess to increase 5-7 days after CMP (central meridian position) passage of solar regions characterized by strong radio emissions at 21 cm. This 21-cm radio flux is attributed to thermal radiation from regions in the corona having about twice the normal electron density and occurring above chromospheric plagues. Plagues have been shown to be identical with regions of enhanced solar magnetic fields. Decimetric radio emission therefore may be considered a particularly sensitive indication of the likelihood of an active solar region producing a geomagnetic disturbance. — D. B. V.

- 184-480. Francis, W. E., and Karplus, Robert. Hydromagnetic waves in the ionosphere: *Jour. Geophys. Research*, v. 65, no. 11, p. 3593-3600, 1960.

A numerical integration of the hydromagnetic wave equations in the ionosphere has been carried out. Tables and graphs are given for the relations between the field amplitudes above and below the ionosphere and for the power dissipated as a function of altitude. The case of a vertically incident plane monochromatic wave near 45° geomagnetic latitude is treated. The results are used to confirm earlier estimates of ionospheric heating by hydromagnetic waves and to estimate the transit time of extremely low-frequency signals. The time delay is found to be approximately 1.4 sec for the ordinary wave and 1.6 sec for the extraordinary wave. This transit time is too short to be significant in the propagation of the sudden commencement of magnetic storms. — D. B. V.

- 184-481. Murakami, Kazuaki, and Kudo, Shoko. The onset times of cosmic-ray storms: *Sci. Papers [Tokyo]*, v. 54, no. 2, p. 155-161, 1960.

The onset times of cosmic-ray storms are investigated with the use of data from detectors located at different places throughout the world. It is assumed that the onset times of cosmic-ray storms occur predominantly within a few hours before or after the sudden commencement of a geomagnetic storm (SC) because in most storms the worldwide component of the cosmic-ray variation begins to decrease with SC. It is observed that among stations at the same latitude the onset time depends on the local time of the station and has a tendency to be early in the morning although the actual moment fluctuates.

To investigate the energy dependency of the onset time, detectors located at the same longitude and sensitive to different energies were used. No definite conclusion could be derived concerning the energy dependency of the onset time, but it was observed that in the initial stage of cosmic-ray storms low energy particles are depressed earlier than high energy particles.

Finally, it is concluded that a diffusion model is the most probable one for the cosmic-ray storm, at least in its initial stage. — V. S. N.

- 184-482. McLean, D. J. Solar radio emission of spectral type IV and its association with geomagnetic storms: *Australian Jour. Physics*, v. 12, no. 4, p. 404-417, 1959.

Type IV solar radiobursts have been identified on radio-spectrographic records at Dapto, New South Wales. They are distinguished from type I storms in several ways, including a remarkably close association with geomagnetic storms. Like some type I storms, all type IV storms are associated with very large solar flares. — D. B. V.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 184-483. Shimizu, Yoshio. Magnetic viscosity of magnetite: *Jour. Geomagnetism and Geoelectricity [Kyoto]*, v. 11, no. 4, p. 125-138, 1960.

The magnetic viscosity of 4 samples consisting of medium-sized grains of natural magnetite was examined at various temperatures in the range of about 100°K-850°K. The magnetic viscosity coefficient S (defined as $I - I_0 = S(Q + \log t)$, where I and I_0 are intensity of magnetization at time t and t_0) was found to be proportional to the external magnetic field and to be a linear function of temperature except at temperatures near the Curie point and at -160°C, so far as the Rayleigh region of magnetization is concerned. S tended to have a finite value if the grain size tended to be of the order of a single domain.

For a group of magnetite grains S is extremely small, and the limit of half life of thermoremanent magnetization is 10^{120} yr. The half life of the "detrital magnetization" of sedimentary rocks, containing grains with scattered magnetization, is calculated to be about 10^{10} yr for $w=1/5$ (w is a reduction factor). These results show that the remanent magnetization of igneous and sedimentary rocks has been extremely stable against thermal viscosity during geologic time; therefore, if proper care is used in sampling, the results of paleomagnetic measurements should be reliable. — D. B. V.

- 184-484. Grabovskiy, M. A., Zherdenko, O. N., and Skovorodkin, Yu. P. O vozmozhnosti primeneniya magnitnogo poroshka pri izuchenii veshchestvennogo sostava zheleznykh rud [On the possibility of application of magnetic powder for study of the composition of iron ores]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 970-973, 1960.

A method of using finely ground magnetite (Fe_3O_4) or iron oxide ($\gamma\text{Fe}_2\text{O}_3$) for microstructural analysis is proposed for determination of magnetic susceptibility. — A. J. S.

- 184-485. Syono, Yasuhiko. Magnetic susceptibility of some rock forming silicate minerals such as amphiboles, biotites, cordierites, and garnets: *Jour. Geomagnetism and Geoelectricity [Kyoto]*, v. 11, no. 3, p. 85-93, 1960.

The magnetic properties of some silicate minerals were examined. The magnetic susceptibility of garnets at room temperature is in good agreement with the theoretical value, whereas in the case of amphiboles, biotites, and cordierites, which contain water in their crystal structure, the magnetic susceptibility at room temperature is larger than expected. — D. B. V.

- 184-486. Kushiro, Ikuo. γ - α transition in Fe_2O_3 with pressure: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 11, no. 4, p. 148-151, 1960.

Experiments show that the temperature of transition of synthetic γ - Fe_2O_3 (maghemite) to α - Fe_2O_3 (hematite) is lowered by increasing the pressure. The transition line is represented by the equation $p=150-0.3T$, where p is pressure in bars and T is temperature in $^{\circ}\text{C}$. The transition of titaniferous maghemite (titanomaghemite) needs higher pressure and temperature than that of pure maghemite. The results suggest that maghemite is formed only near the surface of the earth, at depths of less than 500 m in the crust. — D. B. V.

- 184-487. LeBorgne, E[ugène]. Influence du feu dur les propriétés magnétiques du sol et sur celles du schiste et du granite [Effect of fire on the magnetic properties of soil and on those of schist and granite (with English and Russian summaries)]: Annales Géophysique, v. 16, no. 2, p. 159-195, 1960.

Experiments in the field showed that the effect of combustion on the surface on the magnetic properties of the underlying soil is limited in depth but intense near the surface. Between 0 and 1 cm depth the magnetic susceptibility is increased 2 to 10 times, whereas below 2 cm there is practically no change. Supplementary laboratory experiments showed that the soil must contain iron and the temperature must reach at least 300°C before any noticeable effect on the magnetic properties is produced. The effect is believed to be a series of transformations of the type $\text{Fe}_2\text{O}_3 \alpha \rightarrow \text{Fe}_3\text{O}_4 \rightarrow \text{Fe}_2\text{O}_3 \gamma$ stabilized.

When schist and granite samples that were originally very weakly magnetic were heated to moderate temperatures (up to 700°C) and cooled in the earth's field they acquired a relatively large thermoremanent magnetization. This confirms the fact that metamorphism can affect the magnetic properties of rocks. — D. B. V.

- 184-488. Lindsley, Donald H. Rock magnetism studies in the Spray quadrangle, Oregon: Carnegie Inst. Washington Year Book 58, July 1, 1958-June 30, 1959, p. 250-253, 1959; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1958-1959, 1959.

A brief progress report is given of results from a geologic and magnetic study of Eocene to Miocene basic lava flows in the Spray quadrangle, Oregon. The purpose of the investigation was to determine any properties of lavas related to the magnetic stability or instability that would be useful in choosing rock units for paleomagnetic studies. — V. S. N.

- 184-489. Griffiths, D. H., King, R. F., Rees, A. I., and Wright, A. E. The remanent magnetism of some recent varved sediments: Royal Soc. [London] Proc., v. 256, no. 1286, p. 359-383, 1960.

The remanent magnetism of Swedish and Icelandic varved sediments with average particle sizes between 5 and 25μ is described. Measurements were also made of these sediments redeposited in the laboratory under controlled conditions. In the artificial sediments the inclination of the remanence may be some 20° less than that of the magnetic field, but in natural sediments this inclination error seems never to be more than 5 - 10° . In neither case was the dependence of inclination error on particle size suggested by earlier work (see Geophys. Abs. 176-264) confirmed. Under both natural and artificial conditions, deposition on a sloping bed produces a deviation of the remanence

from the direction for deposition on a horizontal surface. Experiments with running water showed that velocities up to about 30 cm per sec produce deviations of up to about 20° in a direction related to that of flow; the magnitude of this effect is almost independent of velocity over the range of 5-30 cm per sec. It is concluded that deviations of remanence from the field direction are mainly the result of rolling of particles on the bed during the last stage of settling.

From a review of the evidence it would seem possible in principle to determine magnetic secular variation from varved sediments, but a vast amount of data would be required. (See also *Geophys. Abs.* 166-278, -283; 171-261; 176-270). — D. B. V.

- 184-490. Irving, E. Palaeomagnetic directions and pole positions, part 2. Pole numbers 2/1 to 2/41 and 1/71 (m 1): *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 4, p. 444-449, 1960.

Results of paleomagnetic measurements and calculations of pole positions available up to April 1960 are compiled to supplement the first list (see *Geophys. Abs.* 181-384). Where rocks previously studied are resampled so that the primary data are entirely new, the result is given a new list number; when old data are reworked or supplemented, the old number is retained followed by (m 1), signifying the first such modification, and the nature of the change is indicated in the footnotes. This list includes 41 new results and 1 revision. — D. B. V.

- 184-491. Blackett, P. M. S., Clegg, J. A., and Stubbs, P. H. [S.]. An analysis of rock magnetic data: *Royal Soc. [London] Proc.*, v. 256, no. 1286, p. 291-322, 1960.

Paleomagnetic data of the past decade have been reanalyzed, using a minimum number of theoretical assumptions concerning the ways in which the rocks became magnetized and the origin of the geomagnetic field. The results strongly support the supposition that the wide divergence between the directions of the remanent magnetic vectors of older rocks and that of the present earth's field is a systematic rather than a random effect. It appears that (a) the directions of magnetization of the earlier rocks have been changed by some widespread physical or geological processes since the time of their formation, (b) the earth's field has had strong multipolar components in past ages, or (c) a relative drift of the continents across the earth's mantle has occurred.

The third alternative is considered to be the most plausible. If continental drift is the explanation of paleomagnetic results, then it is possible to estimate the ancient latitude and orientation of each continent relative to the earth's axis of rotation, but changes in longitude cannot be revealed by paleomagnetic measurements alone. — D. B. V.

- 184-492. Kropotkin, P. N. Paleomagnetizm i yego znachenie dlya stratigrafii i geotektoniki [Paleomagnetism and its significance for stratigraphy and geotectonics]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 12, p. 3-25, 1960.

The results of paleomagnetic research to date are reviewed. The stratigraphic significance of reversals of the earth's field; remanent magnetization and its stability; the plotting of pole positions; paleomagnetism, paleoclimate, and astronomic data on recent latitude variations; and paleomagnetic evidence of continental drift are discussed. It is concluded that the value of paleomagnetism as a stratigraphic correlation tool is unquestionable, and that the paleomagnetic evidence of large-scale horizontal movements seems to be substantiated by recent geologic and geophysical data. — D. B. V.

- 184-493. Martinez, Joseph D., Statham, Edwin H., and Howell, Lynn G. A review of paleomagnetic studies of some Texas rocks: Texas Univ. Pub., no. 6017, p. 15-47, 1960.

The mechanisms by which rocks acquire permanent or remanent magnetization are reviewed, and the application of measurements of remanent magnetism to location of ancient magnetic pole positions is discussed. Paleomagnetic measurements on sedimentary, many igneous, and some metamorphic rocks from Texas are reported and some discussed in detail. Application of paleomagnetic data for correlation purposes was tested using Tertiary volcanics in the Big Bend National Park.

It is concluded that studies of rock magnetism are of great value in solving broad problems of polar wandering and continental drift, as well as such specific problems as the correlation of volcanic sequences. — V. S. N.

- 184-494. Irving, E., and Tarling, D. H. The paleomagnetism of the Aden volcanics: Jour. Geophys. Research, v. 66, no. 2, p. 549-556, 1961.

The directions and intensities of the natural remanent magnetization of 164 specimens from 12 sites in the Aden volcanics on the Aden Peninsula have been measured. The results provide the first information on secular variation and reversals of the earth's magnetic field in low latitudes during the Late Cenozoic and are also of interest in connection with the origin of the Red Sea. The directions deviate systematically from true north, with an average declination of N. 7° W. This could be due to anticlockwise rotation of Arabia relative to Africa by an amount sufficient to account for the formation of the Red Sea. Other explanations are possible; however, these can be tested only when results are available from northeast Africa. — D. B. V.

- 184-495. Airinei, Ștefan. Magnetizări normale și inverse în regiunea vulcanului andezitic Uroi (regiunea Hunedoara) [Normal and reverse magnetization in the region of the Uroi andesite volcano (Hunedoara region) (with French and Russian summaries)]: Acad. Romîne Studii și Cercetări de Geologie, v. 5, no. 1, p. 169-196, 1960.

The Uroi andesite volcano in Rumania is characterized by positive magnetization toward the periphery of the mass, including the basement, and by negative magnetization in the central part. The annular positive anomalies represent normal thermoremanent magnetization of the cooling period. The negative values in the center represent reverse magnetization, a later phenomenon due to physical-chemical modifications of the basement rocks. These changes are explained by the action of fumaroles altering the rock and by external agents that produce oxidization. It is possible that the process of inversion of the normal thermoremanent field is in progress at the present time. — J. W. C.

- 184-496. Valiyev, A. A. Opyt paleomagnitnogo raschleneniya Marguzarskogo razreza kaynozoysskikh kontinental'nykh molassovykh formatsiy [Experiment in paleomagnetic subdivision of the Marguzar section of the Cenozoic continental molasse formations]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 974-976, 1960.

As a result of paleomagnetic investigation of the molasse section at Marguzar in northern Fergana, variations in magnetic susceptibility and remanent magnetization to a depth of 1,800 m were established. Based on a duration of $0.4 \pm 0.1 \times 10^6$ yr for the Pliocene magnetic epoch, the length of time for

formation of the Marguzar molasse is estimated at 6.4 million years. Valiyev's estimation of the Pliocene magnetic epoch is 0.5 million years, which is in agreement with the result obtained by Khramov (see *Geophys. Abs.* 172-171). — A. J. S.

- 184-497. Bull, C., and Irving, E. The palaeomagnetism of some hypabyssal intrusive rocks from South Victoria Land, Antarctica: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 211-224, 1960.

The magnetic properties of specimens from two quartz dolerite sheets and from a series of older mafic and felsic dikes from South Victoria Land are described. All are normally magnetized and have declinations to the southwest with inclinations between 40° and 75°; the inclinations of the older dikes are lower than those of the dolerites. The age of the dolerite sheets is uncertain, but they are regarded by some as approximately contemporaneous with the Mesozoic dolerite intrusives and basalt flows of India and the southern continents. The pole position corresponding to the magnetization of the dolerites is in the South Pacific Ocean, significantly different from that of the present pole and from the pole positions obtained from the dolerites and basalts of the other southern continents. (See also *Geophys. Abs.* 181-392). — D. B. V.

MAGNETIC SURVEYS

- 184-498. Hull, Paul, and Coolidge, John E. Field examples of nuclear magnetism logging: *Jour. Petroleum Technology*, v. 12, no. 8, p. 14-22, 1960.

Nuclear magnetism logging is based on the behavior of the hydrogen nucleus in a magnetic field. The hydrogen nucleus can be likened to a spinning magnetic top. Just as an ordinary top precesses about the lines of the earth's gravity field, the hydrogen nucleus precesses about the lines of a magnetic field. The frequency of the precession is determined by the strength of the magnetic field, while the time for alignment is a function of the rate of exchange of energy between the precessing nucleus and the surrounding matrix. Conversely, upon removal of an applied magnetic field, protons will return to a disordered state while precessing about the earth's magnetic field lines at a frequency proportional to the earth's field strength. It is this free precession about the earth's field lines that is used in nuclear magnetism logging. By means of an energy source and polarizing coil, a magnetic field is set up within the formation. Upon de-energizing the coil, the freely precessing protons cause flux changes within the coil and induce an alternating voltage at the precession frequency. The initial magnitude of this alternating current is proportional to the number of hydrogen nuclei. Field examples of the application of the method are presented. Permeability can be measured, and hydrocarbons and water can be differentiated with good reliability. — J. W. C.

- 184-499. Brown, R. J. S., and Gamson, B. W. Nuclear magnetism logging: *Jour. Petroleum Technology*, v. 12, no. 8, p. 201-209, 1960.

The nuclear magnetism log is the only log that responds solely to formation fluids. It operates equally well in both oil- and water-base muds and can be used in all kinds of formations except strongly magnetic ones. The free fluid log is believed to indicate a minimum effective porosity in most formations. This log not only delineates fluid-containing zones but also provides excellent curves for correlation. Nuclear magnetic logs may also help distinguish oil and water zones and provide information on permeability and wettability. — J. W. C.

Roy, Amalendu. On some properties of residuals and derivatives. See Geophys. Abs. 184-367.

- 184-500. Jacobsen, P., Jr. An evaluation of basement depth determinations from airborne magnetometer data: *Bol. Inf.*, v. 3, no. 7, p. 199-207, 1960.

Airborne magnetometer data for a portion of the Eastern Venezuela basin were submitted to two different geophysical contractors for independent analysis to evaluate the reliability of interpretations of local basement relief from magnetic data. The study included areas for which considerable knowledge of basement depths and local configuration existed from other sources. Aeromagnetic maps prepared by the contractors are shown and compared with a generalized basement depth map based on seismograph and well information. The interpretations were entirely different, particularly of local basement relief, suggesting either that the techniques used for analyzing the magnetic data are inadequate, or that such detailed interpretation is beyond the resolving power of magnetometer surveys. — V. S. N.

- 184-501. Strakhov, V. N. O vychislenii vertikal'nogo gradiyenta dvukhmernykh magnitnykh poley [On the calculation of vertical gradients of two-dimensional magnetic fields]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 979-987, 1960.

A graphical method for determining the vertical gradient dZ/dy of two-dimensional magnetic anomalies is proposed. A special master chart for computation of H and Z of the anomaly is constructed, and the method of construction is explained. This method was tested at five local anomalies (Shchigry, Panki, Saltykovo, Smorodino, and Yakovlevo) of the Kursk magnetic anomaly. The accuracy was found satisfactory, which indicates that in most of the two-dimensional magnetic anomalies no special measurements of the field's vertical gradient is necessary. — A. J. S.

- 184-502. Pudovkin, I. M. Universal'naya paletka dlya vychisleniya H_a , Z_a , $\partial Z/\partial n$, $\partial Z/\partial x$ na raznyye gorizonty verkhney poluploskosti, po zadannym znacheniyam Z_a na ploskosti nablyudeniya [A universal master chart for calculation of H_a , Z_a , $\partial Z/\partial n$, and $\partial Z/\partial x$ for different horizons of the upper half-plane for given values of Z_a on the observation plane]: *Prikladnaya Geofizika*, no. 26, p. 99-106, 1960.

A master chart for the transformation of a potential function and its derivatives in interpretation of magnetic anomalies is proposed, and its construction is analyzed mathematically. The master chart is called universal because it permits determination of Z_a , H_a , $\partial Z_a/\partial n$, and $\partial Z_a/\partial x$ without the reconstruction of the proposed master charts for given values of Z_a . — A. J. S.

Lliboutry, Louis. Measurement of the movements of a névé by magnetic surveying. See Geophys. Abs. 184-365.

- 184-503. Heinrichs, Walter E., Jr. Mobile magnetometer gives rapid regional coverage: *World Oil*, v. 152, no. 4, p. 82-84, 1961.

The mobile truck-mounted magnetometer has proved a practical exploration tool where detailed magnetic coverage is required on a regional basis. Results are presented of a profile made along 190 miles of highway in north-eastern New Mexico at an average speed of 40 mph. Contoured aeromagnetic

data between Vaughn and Cuervo presented on U. S. Geological Survey Geophysical Maps 16, 17, and 18 correlate precisely with the mobile magnetometer data. — J. W. C.

- 184-504. Brundage, H[arrison] T. Nuclear precession magnetometer successfully field tested: *World Oil*, v. 148, no. 5, p. 127-128, 1959.

The principle of operation of the nuclear precession magnetometer is described, and a schematic diagram of its component parts is given. This instrument provides a quantitative measurement of the earth's magnetic field invariable from one individual instrument to another. It is not sensitive to orientation relative to the earth's magnetic field, provided the latter does not happen to be exactly parallel to the axis of the coil. Data from the nuclear magnetometer are readily interpreted at the time they are read; therefore, it might be possible under certain circumstances to detail areas of interest at the time the anomalies are first noted instead of returning to the area at a later date. Normal accuracy is on the order of 3 gammas but can be reduced to 1 gamma if desired. — J. W. C.

- 184-505. Webster, Jack C. The airborne magnetometer aids in the search for new gold reefs: *Rhodesian Mining Jour.*, v. 32, no. 392, p. 12-15, 1960.

The results of an airborne magnetometer survey of the Far West Rand area, South Africa, for the purpose of delineating the sub-outcrop of the Lower Witwatersrand are reported. Dikes, faults, and basic igneous intrusions were detected along outcrops and sub-outcrops of the Lower Witwatersrand. The results should be useful in locating the gold-bearing Main Reef. Aeromagnetic maps are included. — V. S. N.

Fajkiewicz, Zbigniew. Application of automatic digital computers in interpretation of gravity and magnetic surveys. See *Geophys. Abs.* 184-389.

Visarion, Marius, and Andrei, Justin. New geophysical data on the central zone of the Hațeg depression. See *Geophys. Abs.* 184-406.

- 184-506. Agoshkov, M. I., and Yenikayev, N. B. Kurskaya magnitnaya anomal'ya [Kursk magnetic anomaly]: Moscow, Akad. Nauk SSSR, 40 p., 1959.

A popular account is given of the history of exploration and the current status of development of the Kursk magnetic anomaly. Geophysical and geological prospecting have revealed several iron deposits that are suitable for commercial exploitation. A yearly production of 150-160 million tons is scheduled for 1965. — J. W. C.

Bumasov, A. P. The magnetic and gravitational field of the Baikal in relation to its seismicity. See *Geophys. Abs.* 184-157.

- 184-507. Agocs, W[illiam] B., Hartman, R. R., and Curtis, C. E. Interpretation of airborne magnetometer and scintillation counter survey in four selected areas of Laos: Philadelphia, Pa., Aero Service Corp., 107 p., 1960.

The results are reported of an airborne magnetometer and scintillation counter survey in Laos. Four areas in the north-central portion were covered in detail and 9 single line profiles were made in the central and southern parts of the country terminating at the Mekong River. The purpose of the detailed survey was to determine extensions of known mineralization, concen-

trations of magnetite, structural conditions favorable to nonferrous mineralization, and general geologic conditions. The line profiles were designed to determine geological information that would be helpful in locating oil, water, coal, salt, and potash sources.

The maximum magnetite content of any anomaly is not greater than 4 percent, and the average content is between less than 1 and $2\frac{1}{2}$ percent. The dimensions of most of the bodies suggest large hematite deposits altered from the original magnetite. Several anomalies are best explained as intrusive bodies; therefore, as much of the area is overlain with Paleozoic limestones, the presence of nonferrous mineral deposits is suggested. It is recommended that all the anomalies be field checked, and an order of priority is given. An appendix describing the instruments and their applications is included. — V. S. N.

- 184-508. Geographical Survey Institute. The second order magnetic survey of Japan (3): Japan Geog. Survey Inst. Bull., v. 6, pt. 1, p. 12-22, 1960.

The results of the second order magnetic survey in the Chugoku-Shikoku district in 1956 and in the Kyushu and Izushichito districts in 1957, are reported in tables. Results were reduced to the epoch 1955 using data of the Kakioka Magnetic Observatory; these reduced values are plotted on a base map and isomagnetic lines drawn to represent the most probable features. Maps showing lines of equal declination, equal horizontal intensity, and equal dip are also included. — V. S. N.

MICROSEISMS

- 184-509. Gutenberg, B[eno]. Microseisms, in *Advances in geophysics*, v. 5; New York, Academic Press Inc., p. 53-92, 1958.

This general discussion of the nature and causes of microseisms includes the following subjects: the definition, history, and classification of microseisms; instruments for the investigation of microseisms; artificial causes for microseisms; natural microseisms with periods less than 2 sec, periods 1-3 secs, periods of about 4 sec, periods of 4-10 sec, and periods of 10 sec to several minutes; and theory of microseisms. A list of 182 references is included. — V. S. N.

- 184-510. Darbyshire, J., and Hinde, B. J. Microseisms: Research Appl. Industry, v. 14, no. 1, p. 8-17, 1961.

The origin of microseisms is discussed briefly, and their use for detecting and tracing storms at sea is described. Emphasis is placed on recent work in England. Vertical and horizontal electronic seismographs have been designed and installed at the National Institute of Oceanography for the specific purpose of recording microseisms. The instruments have high magnification and a flat response for waves of periods between 2 and 10 sec; their outputs are recorded on a triple pen recorder. Since 1958, 3 seismographs have been used with automatic analysis by instruments. Examples of the tracking of specific storms from the instrumental records are given. Correlation coefficients are used not only to find the direction of approach of the storm but also the ratio of Rayleigh wave activity to Love wave activity. The distribution of this ratio over the North Atlantic shows that the ratio diminishes away from the recording station. This confirms the view that microseisms form as Rayleigh waves and are converted to Love waves in transit; thus the distribution of their ratio should be useful in studying the nature of the earth's crust. — V. S. N.

- 184-511. Okano, Kennosuke. Direction of approach of microseisms observed by vector seismographs [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 1, p. 37-42, 1960.

To find the origin of microseisms, the arrival directions of microseismic waves must be observed clearly. For this purpose, orbital motions in UP-EW, EW-NS planes were recorded simultaneously by vector seismographs, and the frequency distribution of arrival directions of pure Rayleigh-type waves was investigated. With one exception, all directions found point toward the coast. The frequency of the direction shows a constant pattern of distribution with respect to the coast regardless of the position of a center of low pressure. The particle orbits suggest that microseismic waves do not always come continuously from definite directions. — V. S. N.

- 184-512. MacDowall, J. Some observations at Halley Bay in seismology, glaciology, and meteorology (with discussion): *Royal Soc. [London] Proc.*, v. 256, no. 1286, p. 149-197, 1960.

Considerable microseismic activity was observed at Halley Bay, Antarctica, during the summer season from December to February, particularly during onshore winds (see *Geophys. Abs.* 180-323). Examples of microseisms and wind observations illustrate the nature of their relationship. The short-period three-component Willmore seismograph used on the floating ice-shelf recorded P-waves from earthquakes at most epicentral distances, but S-waves were badly recorded.

The major part of this paper is devoted to the results of elevation, temperature, and accumulation studies on the ice-shelf and to a variety of meteorological observations, made during the International Geophysical Year. — D. B. V.

RADIOACTIVITY

- 184-513. Farley, Thomas A. Half-period of Th^{232} : *Canadian Jour. Physics*, v. 38, no. 8, p. 1059-1068, 1960.

The half life of Th^{232} has been redetermined by ion chamber alpha particle spectroscopy. The average for 12 samples is 1.41×10^{10} yr, with a standard error of 1 percent. This result is in substantial agreement with the half lives of greater uncertainty already reported in the literature. It is concluded that discrepancies between geologic ages determined from Th/Pb ratios and those determined from U/Pb ratios cannot be attributed to an error in the Th^{232} half life value. — D. B. V.

- 184-514. Vogler, Gerhart. Ursachen emanometrischer Anomalien [Origins of emanometric anomalies]: *Zeitschr. Geophysik*, v. 26, no. 2, p. 57-71, 1960.

The assumption that radon anomalies near the surface are due to increased radon diffusion from an underground source is questioned; the small radon diffusion coefficient and the thickness of the fine-grained weathered layer or crevice fillings would largely prevent diffusion of radon to the surface.

Radon profiles were measured over faults with relatively thick and very dense covers, and soil samples were taken at various depths at each measuring point and measured with a Geiger counter after a storage time several times longer than the half life of radon. The conditions of the tests exclude the effect of diffused radon, yet both methods showed a maximum over the faults.

It is concluded that radon accumulates near the surface with the aid of ground water, charged with both stable and active cations, which is carried upward by capillarity and evaporates near the surface. In clays the cations are accumulated by ion exchange. Three mechanisms causing radon anomalies are therefore possible: (1) accumulation of uranium and radium by ion exchange; (2) accumulation of uranium and radium by ion exchange, and radon diffusion; and (3) radon diffusion alone (in rare cases). — D. B. V.

- 184-515. Budde, Ernst. Der Beweglichkeitskoeffizient der Radium-Emanation in Lockergesteinen [The diffusion coefficient of radium emanation in unconsolidated rocks]: *Zeitschr. Geophysik*, v. 26, no. 2, p. 72-76, 1960.

Israëli (see *Geophys. Abs.* 180-330) has questioned Budde's concept that diffusion coefficients on the order of less than $10^{-3} \text{cm}^2 \text{sec}^{-1}$ exist for radon in unconsolidated masses (see *Geophys. Abs.* 174-314). Extensive laboratory measurements on unconsolidated materials consisting of two different layers as well as field experience confirm the existence of a diffusion coefficient of that order. — D. B. V.

- 184-516. Saha, N. K., and Gupta, J. B. The γ/β branching ratio in the decay scheme of K^{40} : *India Natl. Inst. Sci. Proc.*, v. 26, pt. A, p. 486-491, 1960.

The γ/β branching ratio in the decay scheme of K^{40} is determined by the uranium X_2 and Co^{60} comparison methods in thick samples. The ratio comes out to be 0.112 ± 0.007 , with the absolute rates of K^{40} β and γ -disintegration $n_\beta = 28.8 \pm 0.9$ per sec per g and $n_\gamma = 3.22 \pm 0.15$ per sec per g, in good agreement with results of other recent determinations.

From the observed half life of K^{40} and the distribution of potassium in the earth's crust, the heat production of potassium is estimated to be about 0.65×10^{-6} cal per g per yr of the crust; this in only ~12 percent of the heat produced by the uranium and thorium in the crust at present. Since the earth is $\sim 3 \times 10^9$ yr old, the amount of K present at the earth's creation could not have seriously affected the heat balance of the earth's interior.

Since the electron-capture decay of K^{40} produces $\sim 3.2 \text{ Ar}^{40}$ atoms per sec per g, $\sim 3.8 \times 10^{-12}$ cc of argon per g per yr is provided. The total available argon content of the atmosphere can be explained by assuming its liberation from potassium-bearing rocks during volcanic eruptions throughout earth history. — V. S. N.

- 184-517. Bovin, V. P. Metody napravlennoy registratsii γ -izlucheniya [Methods of directional registration of γ -radiation]: *Atomnaya Energiya*, v. 9, no. 6, p. 483-487, 1960.

The main characteristics and parameters of directional radiation receivers are analyzed, and particular attention is given scintillation radiometers of the compensation type. Descriptions are given of the construction of several compensation systems that can be used in various areas of measurement of radioactive elements. — J. W. C.

- 184-518. Zaghloul, Z. M. The distribution of alpha-radioactivity in Lamorna Granite—Land's End: *Royal Geol. Soc. Cornwall, Trans.* (1957-58), v. 19, pt. 2, p. 116-121, 1960.

"Nuclear" type photographic emulsion was used to investigate the distribution of radioactivity in a thin section of Lamorna granite. The sample of granite was collected from the edge of the Land's End granite intrusion on the

southeast side of Land's End Peninsula. A distribution analysis is given, and it is shown that 73 percent of the total alpha-particle emission comes from accessory mineral inclusions in quartz, feldspar, mica, apatite, topaz, cordierite, and andalusite. — V. S. N.

- 184-519. Hamilton, E. Distribution of radioactivity in some fine-grained igneous rocks: *Geol. Mag.*, v. 97, no. 3, p. 255-260, 1960.

The quantitative distribution of alpha particle activity was determined by nuclear emulsion techniques for the following fine-grained igneous rocks: the Loch Ba felsite and Mhoire Choire trachyte from Scotland, an oligoclase andesite and a trachyte from Hawaii, and two basalts from East Greenland. The distribution of radioactivity was found to be comparable to that observed in equivalent coarser-grained rock types, which are more suitable to nuclear emulsion studies. — V. S. N.

- 184-520. Armands, Gösta, and Landergrén, Sture. Geochemical prospecting for uranium in northern Sweden; the enrichment of uranium in peat: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 15, p. 51-66, 1960.

A peat discovered during radioactivity prospecting in the Masugnsbyn area of northern Sweden shows a remarkably high uranium and radon content, related to the occurrence of radioactive springs in the vicinity. The source of the uranium is beneath the cover of postglacial sediments; the radioactive matter is transferred to the peat, the humus of which serves as a collector of uranium. Preliminary laboratory experiments with leaching of uranium from radioactive iron ores from the area showed that waters containing HCO_3^- and having a pH of about 7.5 can leach an amount sufficient to account for the uranium content of the natural waters of the region. — D. B. V.

- 184-521. Miholić, S[tanko]. Secondary enrichment of uranium in sediments: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 15, p. 73-77, 1960.

Drilling in 1958 at the Fojnica thermal springs and Klokoti mofettes in Bosnia provided new information on the secondary enrichment of sediments in uranium by mineral waters (see also *Geophys. Abs.* 175-338). At Fojnica the water issuing from a fault in Carboniferous schists has a radioactivity of 3.640 millimicrocuries per liter and flows over an extensive sinter terrace. The radioactivity of springs in this terrace increases with increasing distance from the fault, due to secondary enrichment of uranium and radium in the sinter.

At Klokoti, carbon dioxide gas from pools in a bog showed a radioactivity of 3.74 millimicrocuries per liter, whereas drilling yielded gas with a radioactivity of 8.526 millimicrocuries per liter; in the borehole the gas can reach the surface before much of the radon has decayed. — D. B. V.

- 184-522. Gabinet, M. P. O radioaktivnosti bituminoznykh porod menilitovoy serii [Radioactivity of bituminous rocks of the Menilitov series]: *Problemy Geokhimii*, no. 1, p. 256-260, 1959.

A study was made of the organic matter of the bituminous argillites of the Menilitov series; the specimens were recovered largely from drill holes. The radioactivity and organic carbon content were determined for 130 specimen, the data for 38 of which are presented in a table. The relatively high radioactivity of these bituminous rocks is attributed to the presence in the same

sedimentary basin of silicic tuffs and bentonitic clays. The radioactive elements in the argillites were adsorbed from the sea water by the clays and fine-grained organic matter. — J. W. C.

- 184-523. Shmonin, L. I., Cherdyntsev, V. V., Kashkarov, L. L., and Ostapenko, V. F. Issledovaniya neytronnogo potoka zemnoy kory [Investigation of the neutron flux of the earth's crust]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 6th sess., p. 234-243, 1957 (1960).

This is the same as the paper previously published in *Geokhimiya*, no. 2, p. 105-109, 1959 (see *Geophys. Abs.* 180-328). — A. J. S.

- Baranov, V[ladimir] I., and Khristianova, L. A. New data on radioactivity of the Indian Ocean. See *Geophys. Abs.* 184-592.

- 184-524. Zartman, R. E., Wasserburg, G. J., and Reynolds, J[ohn] H. Helium, argon, and carbon in some natural gases: *Jour. Geophys. Research*, v. 66, no. 1, p. 277-306, 1961.

The helium, radiogenic argon, and atmospheric argon contents of 39 samples of natural gases representing varied chemical compositions and geological occurrences were determined. The total range in the $(\text{He}/\text{Ar})_{\text{rad}}$ ratio (1.6-130, with most values falling between 6 and 25) is essentially equal to the production ratio from the uranium, thorium, and potassium in average igneous rocks and a wide variety of sediments; this indicates that all of these natural gases have obtained their radiogenic gases from rather average rock types. This is true in spite of the fact that the helium content of the gases ranges from 37 to 62,000 ppm.

The isotopic composition of the carbon in the methane of these gases is very light. For coexisting CH_4 - CO_2 pairs the carbon dioxide was always isotopically heavier. — D. B. V.

- 184-525. Lockhart, Luther B., Jr. Atmospheric radioactivity in South America and Antarctica: *Jour. Geophys. Research*, v. 65, no. 12, p. 3999-4005, 1960.

Information on the concentration of the major natural radioactive species and of gross-fission-product activity in the ground-level air at Lima, Peru; Chacaltaya, Bolivia; Rio de Janeiro, Brazil; and Little America, Antarctica is reported.

The radon content of the air was found to be generally less than that in North America. Thorium seems to be relatively more prevalent in the surface soils there than in North America. In Antarctica the natural activity of the air is extremely low; thoron is a negligible contributor. Fission products are minor contributors to atmospheric radioactivity in the southern hemisphere except in Antarctica, where it assumes relatively more importance compared to the low natural activity present.

Seasonal changes in one or more of the radioactive components are evident at each of the sites. These changes are probably related to meteorological factors and the location of soils rich in radioactive elements, whereas changes in the fission product concentration are related to seasonal changes in the mixing rate of air masses. — D. B. V.

- Van Dilla, M. A., Arbold, J. R., and Anderson, E[rnest] C. Spectrometric measurement of natural and cosmic-ray induced radioactivity in meteorites. See *Geophys. Abs.* 184-97.

Shedlovsky, J. P. Cosmic-ray produced manganese-53 in iron meteorites. See *Geophys. Abs.* 184-98.

RADIOACTIVITY SURVEYING AND LOGGING

- 184-526. Beckerley, J. G. Nuclear methods for subsurface prospecting: *Ann. Rev. Nuclear Sci.*, v. 10, p. 425-460, 1960.

The use of nuclear techniques for measuring in place the properties of subsurface formations is reviewed. Nuclear techniques applied to aerial and surface prospecting are discussed briefly in the introductory section to give a complete and comparative picture. The economic importance of subsurface prospecting and the fundamental limitations of nuclear techniques are indicated; and after a discussion of existing "boundary conditions" in subsurface methods, the status of each nuclear logging method—natural gamma, density (gamma scattering), neutron activation, and neutron capture and inelastic gammas—is considered. Finally, the major gaps in the technique are identified, and the future course of development of nuclear methods in subsurface prospecting discussed. A bibliography of 86 items is included. — V. S. N.

- 184-527. Gregory, A[lan] F. Geological interpretation of aeroradiometric data: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Bull. no. 66, 29 p., 1960.

A new quantitative technique for the interpretation of regional geology from field measurements with integrating detectors is presented. The major determinants of gamma flux density are: the air distance between the source and the detector, the effective radiating area of the source, and the specific surface activity of the source material. Over large air distances, the multiple-scattered radiation approximates a state of spectral equilibrium, and the attenuation of this equilibrium flux may be described by a single, effective absorption coefficient. A mathematical expression is derived for the signal measured over a source, with both area and thickness infinite in extent.

In the interpretive technique, maximum values of signal intensity and flight altitude above ground are used to plot a lithological clearance-signal curve for each rock type in the area. Values of the theoretical signal at the surface of an elementary unit area of source material and of the effective absorption coefficient of its equilibrium flux in air that are characteristic of the rock may be determined from these curves. Accordingly, the automatic correction of data for flight altitude, based on the assumption of a single absorption coefficient, is not valid for comparative aeroradiometry. The lithological clearance-signal data suggest that spectral analysis of gamma radiation may provide useful data for a more detailed geological interpretation than the present technique permits. — V. S. N.

- 184-528. Rothe, Klaus. Problematik radiometrischer Messungen über Ölstrukturen [Problems of radiometric measurements over oil structures]: *Geol. Gesell. Ber.*, v. 4, no. 2/3, p. 183-187, 1959.

A number of oil structures in East Germany have been investigated in order to determine whether radiometric measurements made at the surface can delineate anomalies that indicate the presence of oil. The first tests were made on the old Fallstein oilfield, and in the Diesdorf-Waddekath area. A counting apparatus was carried along foot traverses. The intensity of radioactivity was averaged for every 20 m of traverse in order to eliminate any very local effects. An accuracy of 0.2-0.5 μ r per hr was found to be sufficient. The results show that such radiometric measurements on the ground can definitely be used for oil prospecting. — D. B. V.

- 184-529. Walker, R. Y., and Litzenberg, Samuel R., Jr. New exploration technique shows promising results: *World Oil*, v. 148, no. 5, p. 134-137, 1959.

The emission technique of oil exploration, based on the radiation and detection of low energy (soft) gamma rays from the subsurface, has been field tested in producing areas of Texas, Louisiana, New Mexico, and Oklahoma with good results. This method is particularly useful in outlining the productive limits of fields. Faults are also detected by the gamma radiation from radon gas that passes along the fault plane. The direction of dip of the fault can be determined by the leakage of radon upward from the fault plane on the down dip side. — J. W. C.

Agocs, William B., Hartman, R. R., and Curtis, C. E. Interpretation of airborne magnetometer and scintillation counter survey in four selected areas of Laos. See *Geophys. Abs.* 184-507.

- 184-530. Tittle, C. W. Theory of neutron logging I: *Geophysics*, v. 26, no. 1, p. 27-39, 1961.

An analytical theory of epithermal neutron logging is presented. One-group diffusion theory is applied to the slowing down of neutrons from a point fast neutron source in infinite continuous media, in a single cylinder, and in concentric cylinders representing a fluid-filled borehole and the surrounding formation. Numerical results are given for the epithermal neutron flux in a water-filled hole six inches in diameter, passing through limestone of 10 percent or 30 percent porosity. Preliminary semiquantitative agreement is obtained with the relative response of a commercial logging instrument in the range of 10 to 100 percent porosity. — Author's abstract

- 184-531. Gomonay, V. I., Krivskiy, I. Yu., Ryzhkina, N. V., Shkoda-U'yanov, V. A., and Parlag, A. M. O razgranichenii neftenosnykh i vodonosnykh plastov po sredstvom ispol'zovaniya elektronnykh i fotonnykh puchkov [Delimiting oil-bearing and water-bearing strata by means of electron and photon beams]: *Atomnaya Energiya*, v. 9, no. 4, p. 313-315, 1960.

A direct method of locating the water-oil interface in cased wells may be found in the use of the diverse nuclear properties of isotopes present in the water- and oil-bearing strata. These isotopes differ in the threshold energies of the (γ, n) reactions induced by an electron beam. For example, the carbon isotopes of oil have distinctive threshold energies that stand in contrast to those of the oxygen in water. Consequently, using electron beams on the order of 8 Mev and higher, oil- and water-bearing strata can be recognized. A small-clearance electron accelerator must now be designed for this purpose. — J. W. C.

- 184-532. Androsenko, A. L., Broder, D. L., and Lashuk, A. I. Gamma-luchi, vznikayushchiye pri neuprugom rasseyanii neytronov s energiyey 3 Mev [Gamma radiation produced by inelastic scatter of neutrons with energies of 3 Mev]: *Atomnaya Energiya*, v. 9, no. 5, p. 403-406, 1960.

Results are presented of a study of the gamma radiation arising from inelastic scatter of neutrons in the nuclei of boron, hydrogen, fluorine, sodium, magnesium, aluminum, silicon, phosphorous, sulfur, iron, cobalt, nickel,

copper, zinc, selenium, zirconium, niobium, molybdenum, cadmium, tin, antimony, lanthanum, tantalum, platinum, iron, and lead. A schematic diagram is given of the apparatus, and a table contains data on the energies of the gamma radiation for each of the elements studied. — J. W. C.

- 184-533. Kantor, S. A. O glubinnosti issledovaniya gornyx porod neytron-neytronnym karotazhem [On the depth of investigation of rocks by neutron-neutron logging]: *Prikladnaya Geofizika*, no. 21, p. 111-132. 1958.

Discussing the neutron-neutron method of logging, a kinetic equation is derived for neutrons in cylindrical coordinates, and a method is developed for calculating the effective radius of investigation. — A. J. S.

- 184-534. Williams, Milton. Applications of nuclear science in petroleum production: *Jour. Petroleum Technology*, v. 12, no. 8, p. 11-13, 1960.

Although no application of nuclear science can be said to have revolutionized the operations of the petroleum industry, its contributions have been numerous and distinct; they constitute a real advance. The various fields where nuclear studies have been important are geochronology, well logging, well completion and repair, reservoir performance, and production. — J. W. C.

- 184-535. Moore, E. James, and Holmes, Charles. Interpreting cable tool hole well logs: *World Oil*, v. 148, no. 5, p. 142-147, 1959.

The borehole environment of a cable-tool hole differs from that of rotary holes in that there is no significant invaded zone nor build-up of mud cake, and the resistivity of the borehole fluid changes rapidly with time and depth. Therefore, logging procedures in the cable-tool holes are different. After completion of an oil well with the "dry hole" technique, the hole must be conditioned for electric logging operations; it is filled with fresh water to a depth approximately 100 feet above the section to be logged. The resistivity (R_m) of the fresh logging water decreases continually with time and may vary considerably with depth due to influx of salty formation water. The effective porosity may be determined from radioactivity logs by using the gamma corrected neutron curve; this parameter can then be used to determine permeability and formation factor.

The successfully completed flowing gas well is a "dry hole" completion, and no conditioning of the borehole prior to logging is required. The logging program consists of running a suite of radioactivity and temperature logs designed to determine the average porosity and vertical extent of the gas filled zones. The presence of such zones and the volumetric flow rate of the gas is revealed on the temperature log as a result of marked cooling of the well bore at these levels due to the rapid expansion of the escaping gas. — J. W. C.

- 184-536. Caldwell, Richard L. Tracers in oil wells: *Nucleonics*, v. 19, no. 2, p. 58-63, 1961.

The use of tracers in oil wells is reviewed. Among the many applications, tracers can be used to show the vertical permeability distribution in a well; a permeability profile based on radiotracers is illustrated. The most important uses of this method, however, are in oil-well engineering. — J. W. C.

- 184-537. Tittman, J., and Nelligan, W. B. Laboratory studies of a pulsed neutron-source technique in well logging: *Jour. Petroleum Technology*, v. 12, no. 7, p. 63-66, 1960.

The status of laboratory studies of a radiation logging technique using a borehole accelerator as a neutron source is reported. The accelerator is a small-diameter, cylindrical neutron-generator tube which utilizes the principle of accelerating deuterons by a high voltage and allowing them to bombard a tritium target. The resulting reactions produce large numbers of neutrons of 14 Mev energy. For the experiments being described, neutron-pulse repetition rates in the range between 500 and 5,000 pulses per second are adequate. The environments investigated consisted of 40 percent porous, clean silica sands filled with 15 percent NaCl solution or with No. 2 fuel oil. The curves for the salt-water sand exhibit characteristic peaks for chlorine, oxygen, and silicon; those for the oil sand correspondingly reflect the presence of carbon, oxygen, and silicon. — J. W. C.

- 184-538. Frentrop, Arthur H., and Sherman, Harold. Neutrons from small tubes II. Schlumberger tube: for oil-well logging: *Nucleonics*, v. 18, no. 12, p. 72-74, 1960.

An accelerator neutron source, substituted for the radioactive sources usually used for oil-well logging, offers the advantages of greater source strength, decreased safety hazard, monoenergetic neutron output, and increased information from pulsed operation. A compact neutron-generator tube is described that is intermediate in yield and size between radioactive sources and previous laboratory neutron sources. An applied power of 25-30 w will produce more than 10^8 neutrons per sec in either continuous or pulse operation at temperatures as great as 145°C and for periods of more than 100 hr. — J. W. C.

Plewa, Stanislaw. Geophysical procedures for the determination of coal in Polish boreholes. See *Geophys. Abs.* 184-297.

SEISMIC EXPLORATION

- 184-539. Walter, Edward J. Decay of seismic pulses near the source: *Earthquake Notes*, v. 31, no. 1-2, p. 17-19, 1960.

A series of tests was conducted to measure the attenuation of seismic pulses near the source. The pulses were generated by dropping an 122 lb weight onto an anvil from heights beginning at 5 feet. Measurements were made at 5-ft intervals from 5 feet up to 60 feet after which 10-ft intervals were used up to 120 feet. The data curve when plotted as acceleration versus distance has the appearance of a negative exponential function. A function of the form $ax^k=c$ was assumed, and a good fit for the data was obtained. Values computed for k and c give the equation $ax^{1.725}=3.242$. This function and the data appear linear when plotted in double logarithmic coordinates. The type of function used does not separate geometrical effects and absorption effects but is a useful method for delineating critical values in the region of observation and for small extrapolations. — V. S. N.

- 184-540. Molotova, L. V., and Vasil'yev, Yu. I. O velichine otnosheniya skorostey prodol'nykh i poperechnykh voln v gornykh porodakh. 1. [On the magnitude of the ratio of the velocities of longitudinal and transverse waves in rocks. Pt. 1]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 930-945, 1960.

Methods of determination of v_p/v_s values in rocks are discussed, and improvements consisting of a simultaneous correlated treatment of traveltime curves of longitudinal and exchange-refracted waves are proposed. Five examples of field determination of v_p/v_s are given for layers with depths from

zero to several km. No direct and unique correlation was found between the values of v_p/v_s and those of v_p in the various mediums. For low velocities in dry clastic rocks, v_p/v_s ranges between 1.7 and 1.8. For sandy clay, clay, and weathered rocks the value of v_p/v_s increases when v_p and v_s increases.—A. J. S.

- 184-541. Puzyrev, N. N. Interpretatsiya dannykh seysmorazvedki metodom otrazhennykh voln [Interpretation of data of seismic exploration by the method of reflected waves]: Moscow, Gostoptekhizdat, 451 p., 1959.

The fundamentals of the method of reflected waves are reviewed. Various stages of interpretations, beginning with the correlation of waves through the construction of structural maps, are discussed. Among the topics considered are: tracing of reflections under diverse seismological conditions and control methods of the correlation accuracy according to dynamic and kinematic data; evaluation of accuracy of results obtained at various stages of interpretation and substantiation of more rigid methods for obtaining means of observed data; traveltime curves of reflected and other types of waves, their construction and correction for nonhomogeneous media and curvilinear interfaces; correlation between effective and mean seismic velocities in nonhomogeneous media of various types and for curvilinear interfaces; development of more accurate methods for calculation of effective velocities from the traveltime curves of reflected waves; development of simpler approximate methods in accounting for the nonhomogeneities of media the reflecting boundaries of which are constructed; construction of structural maps and selection of profiles and scales for them; and practical construction of seismic-ray diagrams. A list of 182 references is given. — A. J. S.

- 184-542. Seabrooke, David S. Anomalous events on the reflection seismogram: Geophysics, v. 26, no. 1, p. 85-99, 1961.

Events other than simple reflections are becoming more evident with the advent of magnetic tape and the various types of display sections such as variable area, variable density, and full trace. Multiple reflections, diffractions, and other anomalous events must be recognized if optimum use is to be made of the data. Simple parameters such as arrival time, apparent dip step out, and normal moveout, which are readily obtained from reflection seismograms, permit a quantitative approach to the problem. Events associated with direct, refraction, reflection, and diffraction energy are discussed. — J. W. C.

- 184-543. Fry, John C., and Raitt, Russell W. Sound velocities at the surface of deep sea sediments: Jour. Geophys. Research, v. 66, no. 2, p. 589-597. 1961.

A study of the initial amplitude of reflection of explosive sound from the sea floor in the Pacific has shown many cases in which the amplitude decreases with increasing angle of incidence and becomes negative at angles of about 74° to 80°. If the sediment can be treated as a fluid, the angle of phase change gives a measure of the sound velocity in sediments at the sea floor. Throughout most of the Pacific, velocities average about 2 percent less than the bottom water velocity. At some stations, notably those in the Chilean and Aleutian Trenches, in the Hawaiian Deep, and off the western coast of the United States, sediment velocities were found to be higher than the sound velocity in the overlying water, suggesting the effect of turbidity-current deposits in these areas. Illustrations of these two types of reflection from the sea floor area presented.—Authors' abstract

- 184-544. Van Siclen, DeWitt C. Seismic velocity effects may hide organic reefs: *World Oil*, v. 148, no. 5, p. 118-122, 1959.

A limestone reef near Stamford, Tex., produces a false uplift on seismic maps of horizons below the reef because seismic waves travel much faster through the limestone than through the shale around it. The usefulness of this effect for mapping reefs depends on the degree of velocity contrast between the limestone and shale. Theoretically this contrast decreases with increased porosity of the limestone, as oil replaces water, and as gas replaces oil in the reef, and also as the depth of burial becomes greater. Geologically reasonable changes can be envisaged that would render a reef like that at Stamford practically unrecognizable. In general, the potentially more productive reefs are less likely to be distinguishable.

Numerical models based on the Stamford reef were constructed using Brandt's (1955) formula for the speed of sound in porous granular mediums and with time-average equations. Changes in seismic velocity produced by assumed changes in lithologic and interstitial fluid properties were calculated for the models. These computations should be considered as only semiquantitative. — J. W. C.

- 184-545. Backus, Milo M. Inverse filtering helps solve problem of offshore multiples: *World Oil*, v. 150, no. 6, p. 156-160, 1960.

Water reverberations can be eliminated from marine seismograms by data-processing techniques. The theoretical aspects reported earlier (see *Geophys. Abs.* 177-344) are extended to operational usage. Inverse filtering, when applied to problems of water reverberations, will provide seismic records that are approximately equal to those which would be obtained in the absence of a water layer. These records, however, become less valid as the ocean floor structure becomes increasingly complex. This technique may also have onshore applications. — J. W. C.

- 184-546. Pierau, H., and Müller, W. Improvement in the quality of deep reflections by uniformly linear shotpoint arrays: *Geophys. Prosp.*, v. 8, no. 2, p. 154-163, 1960.

A new shooting technique has proved satisfactory in oil prospecting in north-west Germany in areas unfavorable for reflections. The technique uses uniformly linear shotpoint arrangements that are parallel to and extend the full length of the geophone spread. Charges are detonated simultaneously.

Details of the technique are discussed, particularly the problem of the optimum geophone spreads in continuous profiling, as well as the position of the uphole geophone. Seismograms are reproduced to illustrate the difference in quality of reflections obtained by normal pattern shooting and by the linear shotpoint arrangement. Some special interpretation problems are also mentioned. — D. B. V.

- 184-547. Pierau, H., and Rosenbach, O[tto]. Comparative considerations on the energy content of seismic waves in central and linear pattern shooting: *Geophys. Prosp.*, v. 8, no. 2, p. 164-177, 1960.

This is a continuation of the work by Pierau and Müller on linear shotpoint arrays (see *Geophys. Abs.* 184-546). Theoretical and experimental comparisons are made of the energy content of seismic waves in central and linear shotpoint arrangements. It is concluded that for the same size charge, the energy content of deep reflections is greater in linear than in central pattern shooting, and that seismograms obtained with the linear arrays are less dis-

turbed by surface waves. Therefore, the signal-to-noise ratio is considerably better in the case of linear shooting, giving better quality deep reflections. — D. B. V.

- 184-548. Bortfeld, R[einhard], Hürtgen, H., and Köppel, H. Direction shooting: *Geophys. Prosp.*, v. 8, no. 4, p. 534-562, 1960.

The direction shooting method is described, including all pertinent procedures and proofs. Direction shooting is a method of continuous seismic profiling with shots distributed along the whole length of the geophone spread; the shots are fired either with time delays in the field, or recorded singly on magnetic material and composited with time delays. In this way the subsurface can be probed in any desired direction, enhancing reflections from one direction and attenuating or eliminating events from all other directions. For each reflection, the correct delay can be determined simply from a single trial record. Synthetic and field examples illustrate the efficiency of the method and its resolving power. — D. B. V.

- 184-549. Seelis, Karl-Heinz. Directional scanning when playing-back seismic magnetic records: *Geophys. Prosp.*, v. 8, no. 4, p. 563-575, 1960.

A magnetic playback procedure is described and illustrated by examples, by means of which reflections of appreciably different slopes across the record can be effectively separated from each other. This "skipping-mixing" ("überschlagende Mischung") principle consists of mixing between nonadjacent channels, using either direct, or more often, reversed-polarity mixing signals. — D. B. V.

- 184-550. Berzon, I. S. Seismische Hochfrequenzuntersuchungen [High-frequency seismic investigations]: *Freiberger Forschungshefte C 81 Geophysik*, p. 111-121, 1960.

The high-frequency seismic surveying method is described. The main differences between high-frequency seismic apparatus and the conventional (middle-frequency) instruments is that the former must have frequency characteristics in the range of 70-500 cycles per second, a steep characteristic (up to 30-36 db per octave) in the frequency range below the maximum to cut out low-frequency components, and a greater sensitivity because the high-frequency waves are weaker.

The method is useful for locating water-bearing sandy layers and coal seams, ores, and oil, where detailed subdivision of layers—even in vertical structures—is desired. For very complex structure a combination of high-frequency and middle-frequency methods is usually used.

The high-frequency method was used in the Soviet International Geophysical Year program to measure ice thickness in Antarctica and in glaciers in the Caucasus and Tien Shan. It is a useful method of investigating seismic wave propagation in different rock types because of the excellent resolution of high-frequency waves in seismograms. Many seismograms are illustrated. (See also *Geophys. Abs.* 163-92, 166-338, 175-357, 177-349.) — D. B. V.

- 184-551. Willmore, P. L., and Bancroft, A. M. The time term approach to refraction seismology: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 4, p. 419-432, 1960.

In all seismic refraction surveys, the problem is to determine the constants in a system of equations of the type $t_{ij} = a_i - b_j - \Delta_{ij}/v$, where a_i and b_j

are "time terms" which are characteristic of the shot-point and seismograph station, respectively, Δ_{ij} is the distance between the shot-point and the seismograph, t_{ij} is the time of propagation of a refracted wave, and v is the velocity of propagation of seismic waves in an underlying marker layer. It is shown that the equations can be solved for interpenetrating networks of shot-points and seismographs provided that certain general conditions are satisfied. Factors which determine the uncertainties of the final solution are discussed, and methods of correcting for the effects of steeply dipping boundaries are included. — Authors' summary

- 184-552. Karayev, N. A. Opredeleniye srednikh skorostey po dannym KMPV dlya nekotorykh rayonov Zapadnoy Sibiri [Determination of mean velocities according to KMPV for certain regions of western Siberia]: Prikladnaya Geofizika, no. 27, p. 57-63, 1960.

An approximation method is presented for determining mean velocities in the correlation method of refracted waves (KMPV). In the travelttime curves obtained for 2 regions of western Siberia, it is shown that under favorable conditions the method yields mean velocities within 10 percent error. — A. J. S.

- 184-553. Just, Heinz. Erfahrungen mit der Fallgewichtsmethoden [Experiences with the falling weight method]: Freiburger Forschungshefte C 81 Geophysik, p. 44-52, 1960.

The falling weight method is particularly suitable where the use of explosives is impracticable in investigating the elastic properties of foundations. The use of falling weights is described in connection with checking the construction of a railroad embankment. Different size weights were used, as the effect depends on the nature and density of the material at the point of impact; the less consolidated the sediments, the higher the energies required. A 500-kg weight dropped from 1.60 m gave refractions to a depth of about 30 m. It is not yet possible to reach horizons below the water table. — D. B. V.

- 184-554. Marchetti, M. P. The occurrence of slide and flowage materials (olistostromes) in the Tertiary series of Sicily: Internat. Geol. Cong., 20th, Mexico 1956, (Proc.) sec. 5, v. 1, p. 209-225, 1957.

Thick, continuous, extensive layers of chaotic materials intercalated in the normal Tertiary sedimentary sequence in Sicily are described. These are termed "olistostromes" and their origin is attributed to gravitational sliding, slumping, and flowage.

The average densities of olistostromes are comparable to those of shale, but within them there sometimes occur humps of dense rock ("olistoliths") that can produce sharp gravity anomalies such as that near Roccapalumba in central Sicily. The presence of an olistostrome at the surface does not appreciably affect the transmission of energy in refraction surveys, but reflection surveys are difficult or impossible because olistostromes absorb all the reflected energy, including that coming from the autochthonous formation below. Commonly, the passage from a normal sedimentary area to one with an olistostrome is marked by a sudden absence of reflections. — D. B. V.

- 184-555. Nolting, R. P. Accurate depth determination of the velocity survey well phone: Geophysics, v. 26, no. 1, p. 100, 1961.

Many velocity surveys have been shot in which the actual depth of the well phone was in question at one or more of the levels shot in the borehole. Accurate depth control of the well phone can be established by fully utilizing the geophysical tools that are normally run in the borehole. Most velocity sur-

veys are shot with the well phone and other logging equipment connected into one logging tool; by running a section (100 feet) of one of the standard logs either immediately before or after the check level is shot, this section of log can be correlated to the standard log and depth of the well phone established from this correlation. — D. B. V.

- 184-556. Gretener, [Peter] E. F. An analysis of the observed time discrepancies between continuous and conventional well velocity surveys: *Geophysics*, v. 26, no. 1, p. 1-11, 1961.

Discrepancies between times obtained by conventional well velocity methods and the Shell continuous velocity tool are analyzed and found to be due to a random scatter and a systematic deviation, the integrated continuous velocity curves being short. Possible causes are discussed, but no final explanation is offered. — D. B. V.

- 184-557. Wachholz, Helmut. Geometrische Faktoren bei Akustik-Log-Messungen und ihr Einfluss auf die Messsondenkonstruktion [Geometric factors in acoustic log measurements and their bearing on the construction of measuring probes]: *Erdöl und Kohle*, v. 13, no. 8, p. 545-549, 1960.

The geometric factors in acoustic log measurements are examined and discussed from the standpoint of the instrument maker. After brief mention of the choice of measuring principle, the geometric error in traveltime measurements is treated. The behavior of the traveltime curves in the case of variations in borehole diameter is described for the idealized case of a right-angle step. Different transmitter-receiver arrangements are discussed. Rules for construction and development of acoustic log apparatus are obtained from a comparison of the relative advantages and disadvantages of these arrangements and consideration of the problems imposed by geology and geophysics. — D. B. V.

- 184-558. Młynarski, Stefan. Karota sejsmiczny w latach 1953-1959 na obszarze Polski [Seismic logging in Poland in the years 1953-1959 (with English summary)]: *Przegląd Geol.*, v. 8, no. 10, p. 525-529, 1960.

The distribution of boreholes in Poland that have been logged seismically during the years 1953-59 is discussed and plotted on a map. Field procedures are described and several comparisons of seismic logs are presented. The number of shot wells dropped from 6 per year in 1953-55 to 3 in 1958. The distance between in-hole geophones ranged from 20 to 100 m in the early period, but since 1958 it has been 25-50 m. — J. W. C.

- Tixier, M. P., Alger, R. P., and Tanguy, D. R. New developments in induction and sonic logging. See *Geophys. Abs.* 184-293.

- 184-559. Dow, Willard. A telemetering hydrophone: *Deep-Sea Research*, v. 7, no. 2, p. 142-147, 1960.

A deep, telemetering hydrophone which transmits information acoustically through the water to a surface vessel is described and illustrated. The instrument has the advantage of requiring no electrical cable to the ship, may be quickly hung on any suitable supporting line or wire, and can be made to operate completely free of the ship. Among other applications, the unit may be used to detect sounds reflected from subbottom strata. Luskin and others (1960) using a similar instrument have recorded seismic refraction arrivals

in deep water. Tests are being planned that will combine the instrument with a repetitive pulse source, both submerged near the bottom in deep water. (See also Geophys. Abs. 183-583). — V. S. N.

- 184-560. Behnke, C. Über Speicherung mehrerer durch Flüssigkeitsfunken erzeugten seismischer Impulse auf einem einzigen magnetischen Tonträger [On the recording of several seismic impulses generated by fluid sparks on a single magnetic tape (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 1, p. 24-40, 1960.

A new type of equipment for generating seismic impulses by means of impulse-capacity discharges through a fluid spark-gap is described. The resulting ground motion, perceptible several hundred meters away through solid rock or several kilometers away through a water body, is recorded on magnetic tape. It is possible to amplify real and simultaneous diminution of arbitrary oscillation onsets by multiply recording the same impulse on a single tape. Numerous diagrams, photographs, and reproduction of tapes are presented. — D. B. V.

- 184-561. Seelis, Karl-Heinz. Vorzüge magnetischer Registrierung in der Seismik unter Hervorhebung einiger spezieller Abspielmöglichkeiten [Advantages of magnetic recording in seismic surveying with emphasis on some special playback possibilities]: Erdöl und Kohle, v. 13, no. 7, p. 461-466, 1960.

The possibilities and advantages of playbacks of magnetically recorded seismograms are outlined briefly, and the appropriate circuit for the playback process is illustrated schematically. Some examples of different playback possibilities adapted to actual problems are given; these include statically and dynamically corrected playbacks, playbacks filtered and mixed in different ways, and different styles and scales of recording. Methods of distinguishing reflections from differently-dipping horizons appearing in the same seismogram are mentioned. Real reflections can be distinguished from multiple reflections; in the case of profiles transverse to narrow synclines, the reflections associated with each limb are represented on separate playback series. — D. B. V.

- 184-562. Wood, C. A. Plot seismic data with electronic computers: World Oil, v. 148, no. 5, p. 131-133, 1959.

The large number of repetitious operations involved in plotting seismic data make it a likely possibility for some type of automation. A method is presented here for preparing point-plotted cross-sections using a digital computer and an accounting machine that has been modified to function as a plotting device. The time required in this experimental stage is at present slightly greater than that required to plot the same sections by hand. The accuracy of the computer method is much greater, however, and the time involved should be reduced considerably by research in programming. — J. W. C.

- Heidrich, Werner, and Just, Heinz. The reaction of vibration measuring devices on the results of measurements in ground dynamics. See Geophys. Abs. 184-209.

- 184-563. Gol'tsman, F. M., and Limbakh, Yu. I. Pribor dlya chastotnogo analiza i sinteza neustanovivshikhsya signalov [A device for frequency analysis and synthesis of unstabilized signals]: Prikladnaya Geofizika, no. 21, p. 26-36, 1958.

A device for frequency analysis and synthesis of unstabilized signals is discussed; it allows determination of 73 points in analysis of a seismic spectrum $S(f)$ and 73 points in synthesis of a signal $F(t)$. Operation instructions for the apparatus are given, and examples of analysis and synthesis of signals are presented. The device was tested in the field. The graphs obtained agreed well with those constructed theoretically. — A. J. S.

- 184-564. Slutskovskiy, A. I. O nekotorykh voprosakh effektivnosti chastot-noy selektsii i razreshayushchey sposobnosti seismicheskikh usiliteley [Some problems of the effectiveness of frequency selection and of the resolving power of seismic amplifiers]: Prikladnaya Geofizika, no. 24, p. 3-25, 1960.

The advantages and disadvantages of connecting frequency filters before the loop or in the loop of the seismic amplifier ARU are discussed. A method of computing the optimum frequency for seismic amplifiers for a given frequency spectrum of the signal and interference waves is developed and discussed. — A. J. S.

- 184-565. Polshkov, M. K. K teorii i metodike rascheta reostatnogo usilitelya s polosovym fil'trom [On the theory and method of design of a rheostat amplifier having a band filter]: Prikladnaya Geofizika, no. 24, p. 222-245, 1960.

The theory of design of the stabilized filter amplifier used by seismic stations of the rheostat type having separately regulated filters of upper and lower frequencies and also band filters is discussed. A simplified equivalent circuit of an intermediate cascade rheostat amplifier equipped with a band filter is analyzed mathematically. — A. J. S.

- 184-566. Gaither, V. U. Index of wells shot for velocity (eighth supplement): Geophysics, v. 24, no. 5, p. 944-955, 1959.

Information is tabulated on 516 well velocity surveys not reported in previous indexes. Most of the wells listed were shot between September 1958 and September 1959. Corrections and (or) additional information on 17 previously listed surveys are also given. — D. B. V.

- 184-567. Gaither, V. U. Index of wells shot for velocity (ninth supplement): Geophysics, v. 25, no. 6, p. 1251-1259, 1960.

Information is tabulated on 340 well velocity surveys not reported in previous indexes. Corrections and (or) additional information on 5 previously listed surveys are also given. — D. B. V.

Oliver, Jack [E.], Kovach, Robert [L.], and Dorman, James. Crustal structure of the New York-Pennsylvania area. See Geophys. Abs. 184-424.

- 184-568. Biggs, Maurice, Blakely, Robert F., and Rudman, Albert J. Seismic velocities and synthetic seismogram computed from a continuous velocity log of a test well to the basement complex in Lawrence County, Indiana: Indiana Dept. Conserv. Geol. Survey Prog. Rept., no. 21, 15 p., 1960.

A continuous velocity log of a test well in Lawrence County, Ind., has been analyzed for interval and average vertical velocities from the New Albany shale to the basement complex. Average vertical velocities from a datum within the New Albany shale were 13,500 fps to the Trenton limestone, 14,900

fps to the Knox dolomite, 16,500 fps to the Mt. Simon sandstone, and 16,250 fps to the basement.

A synthetic seismogram was computed from the continuous velocity log data. Comparison with a field seismogram from the Trenton limestone made near the well shows good correlation reflections from the Trenton limestone, the upper and lower parts of the Knox dolomite, the Eau Claire formation, the Mt. Simon sandstone, and a metasedimentary rock unit resting on basalt that is assigned to the basement complex. Although the continuous velocity log does not show a sharp velocity contrast at the top of the metasedimentary unit, the synthetic seismogram demonstrates that energies reflected from a series of small velocity contrasts combine to give a prominent reflection. — D. B. V.

- 184-569. Narans, Harry D., Jr., Berg, Joseph W., Jr., and Cook, Kenneth L. Sub-basement seismic reflections in northern Utah: *Jour. Geophys. Research*, v. 66, no. 2, p. 599-603, 1961.

Seismic experiments were conducted in the Rozel Hills area of northern Utah with small (50-300 lb) charges and geophone spreads of 703-1,324 m in order to determine the possibility of obtaining normal incidence reflections from horizons within the subbasement. The explosion of a 490,500-lb charge at Promontory, Utah, in December 1958 was also recorded by a spread at 412-546 m). In spite of low signal-to-noise ratio and multiple reflections, various reflected events were obtained at both sites. Two of the events yielded horizon depths of about 8.5 and 26.3 km, in close agreement with the depths of refraction horizons derived in the area by Berg and others (see *Geophys. Abs.* 183-395). Evidence of other reflected events suggests that the crustal section may be more complex than is indicated by the refraction studies. — D. B. V.

Kane, M[artin] F., and Pakiser, L[ouis] C. Geophysical study of subsurface structure in southern Owens Valley, California. See *Geophys. Abs.* 184-399.

- 184-570. Ewing, J[ohn] [I.], Antoine, J., and Ewing, M[aurice]. Geophysical measurements in the western Caribbean and in the Gulf of Mexico: *Jour. Geophys. Research*, v. 65, no. 12, p. 4087-4126, 1960.

The data from 48 seismic refraction profiles in the western Caribbean Sea and in the Gulf of Mexico are presented in the form of structure sections crossing the Colombian Basin, Nicaraguan Rise, Cayman Trough, Cayman Ridge, Beata Ridge, Yucatan Basin, Campeche Bank, and Sigsbee Deep. The Cayman Trough has a remarkably thin crust, which suggests that it is a tectonic feature. Although parts of the basins have a relatively thin crust, similar to the oceanic type, the shallower areas are intermediate or almost continental in structure. In the Gulf of Mexico the main basin is similar to typical ocean basins in structure except that the high-velocity crust is overlain by very thick sediments. The depth to the mantle is appreciably greater in the Gulf than in an ocean basin. This may be partly the result of loading by the sediments, but large scale tectonic activity is a more likely cause. The Sigsbee Escarpment, the northern boundary of the main basin, appears to be the surface expression of a fault or sharp flexure in the layers beneath the unconsolidated sediments. — Authors' abstract

- 184-571. Pallister, A. E. The preparation of seismic depth maps in oil exploration: *Alberta Soc. Petroleum Geologists Jour.*, v. 8, no. 9, p. 235-246, 1960.

Sufficient subsurface geologic and seismic velocity controls are now available in western Canada to warrant the preparation of depth maps from seismic reflection results. In order to prepare maps of the actual structure of the reflecting horizon in a seismic survey, the effects of the velocity gradient across the area and of the differential erosion on the Paleozoic surface must be removed. A method of depth conversion of seismic reflection data is suggested that utilizes a regional geologic structure map of a shallow formation on the basis that the major scene of velocity gradient is in the interval between this formation and the surface. Deeper maps are prepared by adding thickness intervals to this regional map, with these intervals being calculated in a series of steps determined by velocity interfaces and recorded reflection times. The method is illustrated with an example from the Innisfail field using seismic reflection times calculated at a minimum number of wells together with a regional Blairmore geologic map. — V. S. N.

- 184-572. Allen, Adrian. Seismic refraction investigations of the preglacial valley of the River Teifi near Cardigan: *Geol. Mag.*, v. 97, no. 4, p. 276-282, 1960.

Two seismic refraction profiles were made across the preglacial valley of the Teifi River, above and below Cardigan, to determine the depth to the bed-rock floor. Results indicate a reasonably long profile gradient of 3-6 feet per mile for the preglacial valley. A comparison of this gradient with that of the lower reaches of modern British Rivers (about 6 feet per mile) indicates that a recent east-west tilt of more than about 1/10 of a degree is unlikely. A relative rise of sea level of between 75 and 107 feet since glacial times is indicated. — V. S. N.

- 184-573. Reinhardt, Hans-Günter. Korrelation eines vermutlich an der Zechsteinbasis liegenden reflexionsseismischen Horizontes im Nordwestteil der Deutschen Demokratischen Republik [Correlation of a seismic reflection horizon probably lying at the base of the Zechstein in the northwest part of the German Democratic Republic]: *Geol. Gesell. Ber.*, v. 4, no. 2/3, p. 169-177, 1959.

A well known deep reflecting horizon, believed to mark the base of the Zechstein, is recorded in the West Mecklenburg, Prignitz, and Altmark areas in East Germany. It has been contoured on the basis of reflection results and seismic velocity measurements. The horizon shows a general rise from northeast to southwest; the maximum depth of 5,000 m occurs in the center of the Pritzwalk gravity high and the minimum south of the Salzwedel in the Altmark. An upwarp extends from the western Altmark into southwest Mecklenburg.

The trend of the isopachs is similar to that of the isogams on the gravity map of East Germany. The coincidence of the maximum depth of the horizon and the longest refraction traveltimes with positive gravity and magnetic anomalies is of particular interest. — D. B. V.

- 184-574. Pepel, Andrzej. Badania sejsmiczne w dolinie Wisły [Seismic studies in the valley of the Vistula (with English summary)]: *Przegląd. Geol.*, v. 8, no. 2, p. 91-92, 1960.

Seismic and resistivity studies were made on the Quaternary deposits of the Vistula valley in 1959; the seismic work is discussed here. Special attention was given to recording the traveltime of elastic waves and to eliminating the effect of the weathered zone. Several velocities corresponding to the surficial layers were distinguished. A boulder clay horizon was traced through the entire area. — J. W. C.

Buben, Jiří. Electronic investigations of strain conditions in the mine bump region near Kladno. See *Geophys. Abs.* 184-583.

- 184-575. Kolgina, A. M. Seysmichnī doslīdzhennya v zonī kontaktu kyslykh ta osnovnykh porīd u rayonī m. Volovars'ka-Volyns'koho [Seismic investigations in the zone of contact between acid and basic rocks in the Volodarsk-Volyn region]: *Akad. Nauk Ukrayin. RSR Heol. Zhur.*, v. 18, no. 6, p. 17-27, 1958.

High frequency seismic surveys were made in the pegmatite area of the Volodarsk-Volyn district in the southwest part of the Ukrainian shield. The maximum frequency that was detectable was less than 100 cycles per second. In some cases better results were obtained by using low-frequency filters. Certain features, such as intense absorption by the rocks, necessitated small-scale spreads; geophones were usually spaced at 2.5 m intervals along profiles 5-10 m apart. Optimum shot-point distance was determined experimentally for each spread, guided by knowledge of the elastic wave absorption, form, position, and size of each pegmatite body. Reflections from distant contacts were clearer than those from nearby ones.

The results show that the high frequency seismic method can be used to locate contacts between rocks of different petrographic composition, such as granite and pegmatite, even when their elastic properties are similar. — D. B. V.

- 184-576. Germanyyuk, M. M., Komissarov, G. I., and Lovitskiy, D. K. Novyye dannyye o geologicheskoy stroynii yugo-vostochnoy Turkmenii [New data on the geology of southeast Turkmenia]: *Geologiya Nefti i Gaza*, no. 2, p. 10-14, 1959.

Structural studies were accomplished in the southeastern part of the Turkmen S.S.R. by a coordinated program of seismic surveying and structural drilling. Several uplifts that are of considerable interest with respect to oil and gas have been revealed on the overall monoclinical dip of the Kara Kum platform. — J. W. C.

- 184-577. Zamarenov, A. K., Broymtan, A. R., Dunayev, V. F., and Skibel'skiy, V. L. O yugo-vostochnom obramlenii Severnogo Pri-kaspiya [Southeast frame of the north Pri-Caspian area]: *Geologiya Nefti i Gaza*, no. 1, p. 26-32, 1959.

A buried anticlinal zone is traced by seismic surveying within the little deformed Tertiary cover of the Ustyurt Plateau. This structure has an inherited Ural Hercynide trend. Three maps are presented in which various seismic reflecting horizons are contoured at either 50 or 100 m intervals. — J. W. C.

Weizman [Veytsman], P. S., Gal'perin, E. J. [E. I.], Zwerjew, C. M. [Zverev, S. M.], Kosminskaja, J. P. [Kosminskaya, I. P.], and Krakshina [Krakshina], R. M. Seismic investigations of the deep structure of the earth's crust, which were carried out in the USSR as part of the International Geophysical Year project. See *Geophys. Abs.* 184-431.

- 184-578. Central Water and Power Research Station Poona. Geophysical investigations at Nagileru crossing, right bank canal, Nagarjunasagar project: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., p. 62-63, 1959.

A seismic refraction survey was made at the site of the proposed aqueduct crossing over the Nagileru River at Nagileru, India, to determine the depth to sound limestone. Results are shown in a cross section. — V. S. N.

- 184-579. Izaki, Akira, and Kaneko, Tetsuichi. Sonic survey on the Strait of Akashi [in Japanese with English summary]: Butsuri-Tanko, v. 13, no. 1, p. 36-45, 1960.

A sonic survey of the eastern half of the Akashi Strait, carried out in 1959, is reported. A continuous seismic profiler (or sparker) was used, and the records obtained were compared with dredged samples and rock cores from the sea bottom. The knowledge obtained of the geologic structure is to be used for designing an interisland railway. — V. S. N.

- 184-580. Kashiwagi, Hideji. Actual result of seismic prospecting in Electric Power Development Co., Ltd. [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 1, p. 73-78, 1960.

Errors in results from seismic prospecting as compared with results from test pits or borings at sites for dams, power stations, surgetanks, tunnels, or sources of concrete aggregate were investigated. It was found that the error in determination of gravel depth is less than that for talus depth, whereas the error in determination of weathered rock depth is larger than that for talus depth. An area of level topography produces less error than one of irregular topography. The ratio of the error has no relation to depth. — V. S. N.

- 184-581. Overeem, A. J. A. van. Sonic underwater surveys to locate bedrock off the coasts of Billiton and Singkep, Indonesia: Geologie en Mijnbouw, v. 39, no. 10, p. 464-471, 1960.

Offshore sonic surveys of bedrock and overlying layers were made to facilitate the exploration and exploitation of the submarine tin placer deposits at Billiton and Singkep, Indonesia. The instrument was operated at a frequency of 6 kc or 11.5 kc, and the pulse length was variable from 1 to 9 milliseconds. Bedrock was reached in almost all places. Because operations can be performed rapidly, the sonic methods provide a comparatively cheap means of determining geologic and geomorphic features that formerly could be found only by extensive drilling. — D. B. V.

STRENGTH AND PLASTICITY

- 184-582. Round, G. F. The shear strength of McMurray oil sands: Canadian Mining Metall. Bull., v. 53, no. 576, p. 233-238, 1960; also in Canadian Inst. Mining Metallurgy Trans., v. 63, p. 145-150, 1960.

In order to obtain values of angles of shearing resistance and initial resistance for the McMurray oil sand for use in general design of mining and processing equipment, the shear strength of this oil sand was measured in a controlled strain type tester modified so that the rate of deformation could be varied between 0.01725 and 0.1869 in. per min. Data are reported in terms of angle of shearing resistance and initial resistance for varying rates of deformation, composition, and temperature. Increase of oil content and decrease of temperature each cause an increase in shear strength. The bulk density range 108.7-109.5 lb per cu ft gave angles of shearing resistance from 30° to 40° and initial resistance values of 0.37-0.85 psi. For the bulk density range 101-102 lb per cu ft, lower values of shear strength were obtained indicating that compaction density is also important. — V. S. N.

- 184-583. Buben, Jiří. Elektronische Untersuchungen des Spannungszustande im Detonations-gebiet bei Kladno [Electronic investigations of

strain conditions in the mine bump region near Kladno]: Freiberger Forschungshefte C 81 Geophysik, p. 53-63, 1960.

In the Kladno coal mining district in Czechoslovakia the ground is constantly in motion; mine bumps occur several times a day and rockbursts, registered at Prague as weak near earthquakes, occasionally cause considerable damage. The nature of the ground motion was studied seismically in place and in the laboratory.

In the laboratory studies it was found that pressures applied slowly produced 60-80 impulses per second with natural frequencies in the 600-1,800 cycles per second range, and that when pressures were applied rapidly the deformational energy took the form of a series of impulses whose frequency of occurrence decreased from the moment of application. From curves plotted on the basis of the results of these measurements, a measuring device could be constructed to give warning when a certain deformation quotient is exceeded.

The mine bumps showed three types of vibrations; the first were relatively regular and weakly damped, the second appeared strongly damped, and the last and most common were very complex. As changes in the form of these signals can be a warning of danger, a monitoring apparatus was developed. It showed that the bumps are less frequent at night than during the day. The energy curve showed a regular sequence of calm periods followed by periods of rockburst or strong bumps. — D. B. V.

- 184-584. Denkhaus, H. G., Hill, F. G., and Roux, A. J. A. Review of recent research into rockbursts and strata movement in deep-level mining in South Africa: Inst. Mining and Metallurgy [London] Trans., v. 68, 1958-1959, p. 285-309, 1959.

A general survey of the various aspects of research into the problem of rock-bursts in South Africa since 1952 and the results so far obtained are given under four main headings: (1) The condition of, and the state of stress in the ground around excavations at depth; (2) properties of rock; (3) investigations into the nature of rockbursts; and (4) methods for ameliorating rockburst conditions. — Authors' abstract

- 184-585. Wakahama, Gorow. Internal strain and changes in the microscopic texture of snow caused by compression: I. Compression of a thin section of snow by a static load. II. Compression of thin section of snow at a constant speed [in Japanese with English résumé]: [Hokkaido Univ.] Low Temperature Sci., ser. A, no. 19, p. 37-71, 73-96, 1960.

When snow is subjected to a load not large enough to destroy its structure, its form is changed slowly by creep. In part 1, the results of a thin section study of deformation in snow under compression by constant static loads are reported. Deformation of the compact snow is found to be due mainly to basal slip, slip at grain boundaries and separation of ice grains along weak textural lines. The viscosity of the snow, derived from creep curves, agrees well with Kojima's (1956) results from study of a natural snow layer; snows of the same density may vary in viscosity with variation in size distribution of ice grains.

In part 2, the results of a thin section study of deformation of snow compressed at a slow speed (0.02 mm per min) are reported. In the early stage the section undergoes elastic compression resulting in displacement of ice grains; after the yield point, plastic compression begins and slip lines appear parallel to the basal plane of the ice grains. With further compression many other kinds of deformation appear. In most cases grain boundaries migrate

from the grains of less marked slip lines toward the ones with stronger slip lines. Poisson's ratio for plastic compression of the snow was found to be 0.25-0.35 in agreement with Kojima's results from natural snow on a slope. — V. S. N.

SUBMARINE GEOLOGY

- 184-586. Shepard, Francis P. The earth beneath the sea: Baltimore, Johns Hopkins Press, 275 p., 1959.

This is a popularized but more up-to-date version of Shepard's earlier book, "Submarine Geology" (see Geophys. Abs. 137-11150). The text includes eleven chapters as follows: Waves and currents modify the sea floor; catastrophic waves from the sea; our transient beaches; the continental shelves that surround the lands; origin of continental shelves; the world's greatest slopes; canyons of the sea floor; the deep-ocean floor; under the ocean bottom; coral reefs and their undersea wonderlands; and using the present sea-floor deposits to interpret the past. — V. S. N.

- 184-587. Menard, H[enry] W. The East Pacific Rise: Science, v. 132, no. 3441, p. 1737-1746, 1960.

The results of the Scripps Expedition Downwind and others before and after are combined to give a progress report of research on the East Pacific Rise. The location and topography, seismicity, and crustal section of the rise are described, and then attention is focused on three questions: Does the rise extend under western North America? Are transverse wrench faults part of the rise structure? What is the origin of the rise?

The rise, identifiable as an elevated region with a seismically active crest and high heat flow, extends from the south Pacific under western North America and into the northeasternmost Pacific. The corresponding elevation of the mantle that is found in the oceanic regions has not been found under the intervening continent. The rise is probably genetically related to fracture zones; thinning of the rise crust seems to require large horizontal movements on the flanks with differential movement between blocks, and the fracture zones have the right geographic distribution and magnitude to be the boundaries between displaced blocks.

The hypothesis of a youthful convection current in the mantle suggested by Bullard and others to explain high oceanic heat flow (see Geophys. Abs. 176-207) offers a simple qualitative explanation of all the facts concerning the East Pacific Rise. If a random distribution of relatively short-lived "oceanic" rises is accepted, the picture is compatible with continental drift. It appears probable that most rises are centered in ocean basins because the margins of the basins have been adjusted by convection currents moving out from the center. If so, the African and East Pacific rises may mark relatively young or rejuvenated currents which have not yet had time to produce continental displacement. Even so, east Africa is being torn by deep rifts and Baja California has almost been separated from North America along the crest of the East Pacific Rise. — D. B. V.

- 184-588. Gems and Minerals. Great underwater geological feature traced: Gems and Minerals, no. 279, p. 14-15, 1960.

The expeditions in the Pacific conducted by the Scripps Institution of Oceanography during the International Geophysical Year have resulted in evidence of one of the largest physical structures on earth, the East Pacific Rise. It extends in a sickle-shaped curve for 8,000 miles or more from near New Zealand to the coast of Mexico where its crest disappears; some scientists believe

the crest underlies western North America in which case this crest reappears in the shoal area off the coast of Canada and reaches almost to Alaska. The Rise is the site of many shallow earthquakes; beneath its crest the crust of the earth is only 2 miles thick; the rate of heat flows through its crest is 8 times that in the deep ocean floor or on land and on the flanks is much less than elsewhere; and it is intersected by at least 11 fracture zones trending almost due east-west, which contain most of the volcanoes of the eastern Pacific. Magnetic anomaly maps show north-south trending anomalies whose continuity is interrupted by the fractures. The original patterns can be reconstituted by shifting the maps back and forth, showing that blocks of land as large as Texas have been moved several hundreds of miles. — V. S. N.

- 184-589. Menard, H[enry] W. Consolidated slabs on the floor of the eastern Pacific: Deep-Sea Research, v. 7, no. 1, p. 35-41, 1960.

Tabular masses, largely phillipsite coated with manganese oxide, are abundant on the floor of the eastern Pacific Ocean. The size range of the specimens described in the included table is from 61X61X32 cm down to 3X4X2 cm. They appear to be remnants of layers of volcanic ash derived in large part from volcanoes within the basin. Some of the ash may correlate with the Worzel ash of Central and South America. — V. S. N.

- 184-590. Fairbridge, Rhodes W., and Stewart, Harris B., Jr. Alexa Bank, a drowned atoll on the Melanesian Border Plateau: Deep-Sea Research, v. 7, no. 2, p. 100-116, 1960.

The Melanesian Border Plateau covers an area 1,000 by 200 miles along the northeastern edge of Melanesia and occurs at an average depth of 2,700 m. It has an E-W trend and is broken up into a series of narrow en echelon ridges and troughs approximately 250 by 100 miles in dimension. The troughs rarely exceed 4,000 m in depth; some are closed basins, whereas others open out into a funnel shape and slope gradually down into the Central Pacific Basin to the north. Although the plateau is bordered by the andesite line there is an anomalous absence of deep trenches on the basin margin. The ridges are capped by a few small volcanic islands and a large number of slightly submerged atolls of dead corals. Alexa Bank is a characteristic example. Vulcanism and foul upwelling are possible explanations of the cause of the coral death. — V. S. N.

- 184-591. Starik, I. Ye., Kuznetsov, Y. V., Lisitsyn, A. P., Grashchenko, S. M., and Frenkikh, M. S. O tempakh sedimentatsii v yuzhnoy chasti Indiyaskogo okeana [On the rate of sedimentation in the southern part of the Indian Ocean]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 370-391, 1958 (1960).

A study of sedimentary deposits on the floor of the Indian Ocean is reported. The basic features of the submarine relief are described, and present sedimentation is discussed. The rates of sedimentation at 26 stations in the Indian Ocean were determined by measuring the radioactivity in the core sample, and then by comparing this with the concentration in a reference sample, the accurate sedimentation rate of which was determined by other methods. — A. J. S.

- 184-592. Baranov, V[ladimir] I., and Khristianova, L. A. Novyye dannyye o radioaktivnosti Indiyaskogo okeana [New data on radioactivity of the Indian Ocean]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 392-410, 1958 (1960).

The concentrations of uranium, thorium, ionium, and radium in the cores taken from the Indian Ocean floor are reported. The average rate of sedimentation of ooze was found to range between 1,000 and 2,000 yr per 1 cm. Diatom, foraminiferal, and limey clay oozes were found to be 10 times less radioactive than the red oceanic ooze. — A. J. S.

- 184-593. Laughton, A. S. An interplain deep-sea channel system: Deep-Sea Research, v. 7, no. 2, p. 75-88, 1960.

The system of channels connecting the Biscay and Iberia abyssal plains is described. The two plains are separated by only 40 miles but have a difference in elevation of 100 fathoms with the change of level occurring where the two main channels first leave the upper plain. The total length of channels between the plains is 50 miles with the channels joining at the end of 20 miles; the widths vary from 2 to 10 miles and show meander formation similar to subaerial rivers.

It is concluded that turbidity currents initiated on the continental shelves and flowing across the Biscay Plain are rejuvenated by the increase in gradient and lateral constriction and flow through to the Iberia Plain where they deposit their load. — V. S. N.

- 184-594. Laughton, A. S., Hill, M[aurice] N[eville], and Allan, T. D. Geophysical investigations of a seamount 150 miles north of Madeira: Deep-Sea Research, v. 7, no. 2, p. 117-141, 1960.

An elongated seamount rising to 678 fathoms was surveyed by echo-sounding, dredging, photography, magnetic and seismic methods, the results of which are described. The feature appears to be the result of volcanic extrusion along a fault running obliquely across a broad rise. — Authors' abstract

- 184-595. Klenova, M. V. Geologiya Barentsova morya [Geology of the Barents Sea]: Moscow, Akad. Nauk SSSR. 367 p., 1960.

The geology of the Barents Sea is reviewed comprehensively. The chapters cover the following: geology of the coast and origin of the sea, relief of the sea floor, physical geographic features, investigation of the sediments, distribution of sediments in relation to relief, mineral composition of the sediments, chemical composition and chemical processes in the sediments, and stratigraphy of the sediments. — J. W. C.

VOLCANOLOGY

- 184-596. Macdonald, Gordon A. Volcanology: Science, v. 133, no. 3454, p. 673-679, 1961.

Volcanoes furnish clues to the nature of the earth's interior. The major problems of volcanology are today, as they always have been, the origin of the volcanic heat, the locus and origin of magma, the mechanics of its rise to the earth's surface, the processes that account for the considerable range in composition of magmas that reach the surface, the subsurface structure of volcano systems, and the origin of the water that forms the major portion of volcanic gases. These problems are reviewed briefly, showing the complex interplay of various scientific disciplines within the field of modern volcanology. — D. B. V.

- 184-597. Ishikawa, Toshio, and Katsui, Yoshio. Some considerations on the relation between the chemical character and the geographical po-

sition of the volcanic zones in Japan: Hokkaido Univ. Faculty Sci. Jour., ser. 4, v. 10, no. 1, p. 163-182, 1959.

A petrochemical classification of the volcanoes of Japan and the Kurile Islands is proposed. The major zones proposed are as follows: volcanoes on the Kurile arc; volcanoes on the northern Honshu arc; volcanoes within the Fossa Magna region and on the Izu and Iwo-Jima islands; and volcanoes of southwest Japan. A study of the chemical composition of the lavas of each zone shows that the volcanoes on the outer (southeast or Pacific) side are more calcic than those on the inner (northwest) side. The Japanese trench lies immediately outside the most calcic zone, and it is suggested that the magmatic character of the volcanoes is closely related to their tectonic position. This is further demonstrated by the fact that among quaternary volcanoes of Japan those made up of the more calcic lavas occur on the outer side. Moreover, Rittmann (1953) has shown that the calc-alkaline character of the magmas of the Indonesian volcanoes decreases regularly from the foredeep to the hinterland. — V. S. N.

184-598. Decker, Robert [W.]. Renewed activity of Anak Krakatau: Univ. Indonesia, Inst. Tech. Bandung, Dept. Geology Contr., no. 34, 5 p., 1959.

Anak Krakatau is a cinder cone located in the submerged caldera formed by the catastrophic collapse of Krakatau in 1883. This cone first appeared in 1927, and its last reported activity was in September 1953. Renewed activity was observed in June 1959 during a reconnaissance flight over the area. Four cycles of vulcanian-type eruption took place during a 30-min period. Photographs show various stages of this activity. — J. W. C.

184-599. McCall, G. J. H. The Menengai caldera, Kenya Colony: Internat. Geol. Cong. 20th, Mexico 1956 [Proc.] sec. 1, v. 1, p. 55-69, 1957.

Menengai is one of many volcanoes, now reduced to fumarole activity, situated on the floor of the Gregory Rift Valley in Kenya. It is a caldera of Krakatoa type, formed as a result of rapid emptying of the magma chamber. During the later stages of a sequence of trachyte eruptions, explosions scattered pumice and ash over the surrounding country; the superstructure was left unsupported and the central area of the volcano foundered piecemeal until a vast caldera (more than 35 mi²) was formed. The evidence for the subsidence is still perfectly preserved in scalloped facets, partially foundered and inwardly tilted blocks, and lateral grabens.

Secondary eruptions along a north-south zone traversing the caldera have piled up flows within the caldera and spilled lava down the outer slopes from fissures. These eruptions continued until about a hundred years ago. The age of caldera formation can be dated by lithologic correlation of Menengai ash deposits with the Makalian ash (8000 B. C.) as about 10,000 yr old or possibly less. — D. B. V.

184-600. Tanaka, Y[utaka]. Investigation of volcanic activity of Torishima (II). On the earthquakes near Torishima [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 1, p. 1-8, 1960.

About 60 percent of the volcanic earthquakes at Torishima belong to swarms of shocks, and their occurrences may be expressed as $NPt^{1.5} = \text{const.}$, where NP is the number of volcanic earthquakes, and t is the time interval between successive shocks. The frequency curve of the volcanic earthquakes has 3

local maximums that are related to tidal phases—at 2-3 hr before and 2-3 hr after high tide and at low tide. About 14 percent of the earthquakes are closely related to the tide.

A close relationship exists between the deep-focus earthquake zone and the Fuji volcanic zone which extends through the island of Torishima. Eruptions in 1902 and 1939 at Torishima were accompanied by many deep-focus earthquakes. — V. S. N.

- 184-601. Takeyama, I., Tanaka, Y[utaka], and Kobayashi, E. On the seismic waves and air-shocks caused by the explosion of Volcano Asamayama, Nov. 10, 1958 [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 2, p. 45-53, 1960.

The results of analysis of the seismic waves and air-shocks produced by the explosive eruption of Mount Asama, Japan, on November 10, 1958, are summarized. Seismic wave analysis indicates the presence of two layers under Mount Asama. The thickness of the upper layer is about 7-8 km; the velocities of \bar{P} , \bar{S} , P , and S are 4.5, 2.7, 5.8, and 3.6 km/sec, respectively; and Poisson's ratio in the upper layer is 0.23 and that of the lower layer 0.18. One of the air-shock waves had a period of 5 sec and velocity of 350 m per sec, and the other a period of <0.5 sec and velocity of 320 m per sec. The energy of the explosion earthquake is estimated at about 4×10^{19} ergs. In the first outer zone of audibility, sounds were heard 2 or 3 times. The second outer zone of audibility was separated from the first by a wide zone of silence. The air-vibration (period 0.5-1 min, propagation velocity 280 m per sec) was recorded by barographs and microbarographs at many weather stations. The energy of the first shock of air-vibration is estimated at 10^{17} - 10^{18} ergs. — V. S. N.

- 184-602. Kamo, Kosuke. On the long-period volcanic micro-tremors at Volcano Aso: Volcanol. Soc. Japan Bull., v. 5, no. 1, p. 35-48, 1960.

The results of a study of the long-period microtremors associated with the volcanic activity of Mount Aso, Japan, since 1958 are reported. The long-period microtremors observed before the eruption of June 24, 1958, had a period of 40-55 sec. About 20 hr before the eruption the wave trains were composed of 3 or 4 crests and troughs; about 5 hr before they were characterized by 6 or 7 crests and troughs; and about 1 hr before they decayed. It is believed that these microtremors were not induced by the volcanic microtremors of shorter periods but were due to the state of the magma beneath the crater. — V. S. N.

- 184-603. Nakamura, Hisayoshi; Ando, Takeshi; Sumi, Kiyoshi; and Suzuki, Takashi. Geology and hot springs of Takinoue geothermal area, Iwate Prefecture: Japan Geol. Survey Bull., v. 11, no. 2, p. 79-84, 1960.

Fumaroles and hot springs of the Takinoue geothermal area along the Kakonda River, Iwate Prefecture, Japan, issue from Tertiary sediments, lava, and tuff overlain by Quaternary andesite and are distributed along anticlinal axes and faults. It is not known whether or not the porous Tertiary beds form a reservoir for the natural steam or hot water. — V. S. N.

- 184-604. Nakamura, Hisayoshi; Ando, Takeshi; and Suzuki, Takashi. Geology and hot springs of Kuroyu geothermal area, Akita Prefecture: Japan Geol. Survey Bull., v. 11, no. 2, p. 85-88, 1960.

The hot springs of the Kuroyu geothermal area, Akita Prefecture, Japan, occur along the Sendatsu River in an area of Tertiary tuff, tuffaceous sand-

stone, mudstone, and shale overlain by Quaternary volcanic detritus. One group of springs is characterized by high contents of Cl^{-1} and HCO_3^{-1} ; a second group is accompanied by fumaroles. The hot spring reservoir has not been determined. — V. S. N.

- 184-605. Seno, Kinzo, and Yuhara, Kozo. Study of fumarole (Pt. 1). Vertical temperature distribution in steam wells: Volcanol. Soc. Japan Bull., v. 5, no. 1, p. 1-8, 1960.

The vapor temperature in a well bored in a thermal area rises in general with depth, but the temperature gradient varies with the flow rate, the temperature of the vapor, and the geothermal condition of the surrounding rocks. If ground temperature and vapor temperature in the well are approximately the same, the steam is cooled only by adiabatic change; if ground temperature is lower than vapor temperature, cooling by the surrounding rocks may control the vertical temperature distribution. Three wells (Geyser 4, Beppu-Hakuryu, and Kuzyu-Otake 3) are cited as examples. — V. S. N.

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GEOLOGICAL SURVEY BULLETIN 1146-B



Geophysical Abstracts 185 April-June 1961

By JAMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, and others.

G E O L O G I C A L S U R V E Y B U L L E T I N 1 1 4 6 - B

*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



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UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

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Thomas B. Nolan, *Director*

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GEOPHYSICAL ABSTRACTS 185, APRIL-JUNE 1961

By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others

INTRODUCTION

Extent of Coverage

Geophysical Abstracts includes abstracts of technical papers and books on the physics of the solid earth, the application of physical methods and techniques to geologic problems, and geophysical exploration. The table of contents, which is alphabetically arranged, shows the material covered.

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memorandums) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

List of Journals

Lists of journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033-A) and subsequent issues through 175 (October-December 1958, Bulletin 1086-D) have been compiled into a single list, which may be obtained by writing the U.S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 175. The following is an additional supplement that lists references cited in Geophysical Abstracts 185 that have not been listed previously.

- Addis Ababa Univ. Coll., Geophys. Observatory Bull. -- Bulletin of the Geophysical Observatory, Addis Ababa University College. Addis Ababa, Ethiopia.
- Akad. Nauk Uzbek. SSR Izv., Ser. Geol. -- Akademiya Nauk Uzbekskoy SSR, Izvestiya, Seriya Geologicheskaya [Academy of Sciences of the Uzbek S.S.R., Bulletin, Geological Series]. Tashkent, Uzbek S.S.R.
- Annales Astrophysique -- Annales d'Astrophysique. -- Revue Internationale Bimestrielle. Publiée par le Centre National de la Recherche Scientifique et Éditée par Son Service d'Astrophysique [Annals of Astrophysics. International Bimonthly Review. Published by the National Center of Scientific Research and edited by its Astrophysics Service]. Paris, France.
- Bol. Tecn. Petrobrás -- Boletim Técnico da Petrobrás. Publicado pelo Centro de Aperfeiçoamento e Pesquisas de Petróleo com a Colaboração dos Órgãos Técnicos de Empresa [Technical Bulletin of Petrobrás. Published by the Center of Petroleum Development and Investigation with the Cooperation of the Technical Organ of the Enterprise]. Rio de Janeiro, Brazil.
- Edmonton Geol. Soc. Quart. -- Edmonton Geological Society Quarterly. Edmonton, Alberta, Canada.
- [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech. -- Bulletin d'Informations Scientifiques et Techniques. Commissariat à l'Énergie Atomique [Bulletin of Scientific and Technical Information. Atomic Energy Commission]. Paris, France.

- Geog. Rev. Japan -- Geographical Review of Japan [Chirigaku Hyoron]. The Association of Japanese Geographers, Institute of Geography, Faculty of Science, University of Tokyo. Tokyo, Japan.
- Geologica Ultraiectina -- Geologica Ultraiectina. Mededelingen van het Mineralogisch-Geologisch Instituut der Rijksuniversiteit te Utrecht [Bulletin of the Mineralogical-Geological Institute of Rijks University in Utrecht]. Utrecht, Netherlands.
- Inst. Petroleum Rev. -- The Institute of Petroleum Review. London, England.
- Mining Engineer -- Mining Engineer. The Institution of Mining Engineers. London, England.
- Northern Rhodesia Geol. Survey Recs. -- Records of the Geological Survey, Northern Rhodesia Ministry of Labour and Mines. Lusaka, Northern Rhodesia.
- Oceanographia Sinica -- Oceanographia Sinica [Chinese Oceanography]. Private Research Publication in Cooperation with the Overseas Branch of the National Academy of Peiping and Académie et Bibliothèque Sino-Internationales. Taiwan, China.
- Offshore -- Offshore. Industrial Trade Publications. Conroe, Texas.
- Prog. Theoretical Physics -- Progress of Theoretical Physics, Research Institute for Fundamental Physics, Physical Society of Japan. Kyoto, Japan.
- Tokyo Univ. Fac. Sci. Jour. -- Journal of the Faculty of Science, Tokyo University. Tokyo, Japan.

Form of Citation

The abbreviations of journal titles used are those used in the U. S. Geological Survey publications and in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board of Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991-A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

Abstracters

Abstracts in this issue have been prepared by H. Faul, E. C. Robertson, A. J. Shneiderov, and H. C. Spicer, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstractor following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 185-1. Kulp, J. Laurence, Geologic time scale: Science, v. 133, no. 3459, p. 1105-1114, 1961.

Available pertinent isotopic age measurements are evaluated and the most probable geologic time scale is constructed. Those samples that appear to be most definitive are listed in a table and described briefly in an appendix. In the new time scale the Cenozoic and Cretaceous are much better defined than any other parts. No data exist for the Silurian, and only a few quantitative points are available for the Cambrian, Ordovician, and Triassic. The length of the major periods averages about 60 million years, with surprising uniformity. The division into Early, Middle, and Late clearly does not, on the basis

of biostratigraphic considerations, represent equal or even similar time intervals. The geologic time scale has developed to the place where it can be used for correlation problems in paleontology, orogeny, and mineralization. — D. B. V.

- 185-2. Aldrich, L. T[homas], Wetherill, G[eorge] W., Bass, M[anuel] N., Tilton, G[eorge] R., and Davis, G. L. Mineral age measurements and early history: Carnegie Inst. Washington Year Book 59, p. 208-221, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-60, 1960.

Age measurements made by the same method may give information about two fundamental geological questions: (1) Is the mineral-forming process an essentially continuous one, and (2) are there discrete epochs of tectonic activity between quiescent periods? The time distribution of Rb-Sr ages on a world-wide basis, classified by continents, indicates significant epochs at 1,000 and 2,600 million years occurring in nearly all continents. Detailed studies carried out in the past year on basement rocks from Michigan, Ohio, West Virginia, Missouri, Iowa, Finland, and Saudi Arabia are discussed. (See also Geophys. Abs. 185-10.) — V. S. N.

- 185-3. Vinogradov, A. P., and Tugarinov, A. I. Nekotoryye opornyie opredeleniya absolyutnogo vozrasta (k mirovoy geokhronologicheskoye shkale) [Some marker determinations of absolute age (for a world geochronological scale)]: Akad. Nauk SSSR Doklady, v. 134, no. 5, p. 1158-1161, 1960.

The following partial geochronological scale is established on the basis of absolute age determinations of critical samples made in U.S.S.R. laboratories by the lead isotope and K-Ar methods: $3,500 \pm 300 \times 10^6$ yr, lower boundary of Katarchean (Kolan); $2,700 \pm 150 \times 10^6$ yr, Katarchean-Archean (Rhodesian); $1,900 \pm 100 \times 10^6$ yr, Archean-Early Proterozoic (Belomorian); $1,150 \pm 50 \times 10^6$ yr, Early Proterozoic-Late Proterozoic (Ulkan or Grenville); $650 \pm 50 \times 10^6$ yr, East Aldan (Katangan); $430 \pm 20 \times 10^6$ yr, Late Caledonian; $350 \pm 20 \times 10^6$ yr, Early Hercynian; $250 \pm 10 \times 10^6$ yr, Late Hercynian. — D. B. V.

- 185-4. Kommissiya po Opredeleniya Absolyutnogo Vozrasta Geologicheskikh Formatsiy. Geokhronologicheskaya shkala v absolyutnom letoisshislenii po dannym laboratoriy SSSR na 1960 g. [Geochronological scale in absolute age calculations according to data of laboratories of the U.S.S.R. as of 1960]: Akad. Nauk SSSR Izv. Ser. Geol., no. 10, p. 17-21, 1960.

An absolute geological time scale has been drawn up by the Commission on the Determination of the Absolute Age of Formations of the Academy of Sciences of the U.S.S.R., based on 58 selected K-Ar age determinations made at different U.S.S.R. laboratories. The decay constants $\lambda_K = 5.57 \times 10^{-11} \text{yr}^{-1}$ and $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$ were used. According to this 1960 time scale, the lower boundaries of the geologic time units are as follows (in millions of years): Pliocene 10, Miocene 25, Oligocene 40, Paleocene 70, Late Cretaceous 100, Early Cretaceous 140, Jurassic 185, Triassic 225, Permian 270, Carboniferous 320, Devonian 400, Silurian (Gotlandian) 420, Ordovician 480, Cambrian 570, Precambrian IV (Riphean, Sinian, Late Precambrian, Proterozoic II) 1,100-1,200, Precambrian III (Proterozoic I) 1,800-1,900, Precambrian II (Archean) 2,600-2,700, and Precambrian I (Katarchean) 3,400-3,500. — D. B. V.

- 185-5. Semenenko, M. [N.] P. *Heokhronologichna shkala SRSR* [The geochronological scale of the U.S.S.R. (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 6, p. 17-23, 1960.

At the ninth session of the Commission for the Determination of the Absolute Age of Geologic Formations of the U.S.S.R., an absolute geochronological scale was worked out and accepted. Two values for the lower boundary of the Paleozoic figured in the discussions; in the Urals, Caucasus, and Ukraine the boundary is some $30-60 \times 10^6$ yr younger than in Kazakhstan and Czechoslovakia. The accepted value is $540-600 \times 10^6$ yr.

The Precambrian is divided into 4 groups with the following lower time boundaries (in millions of years): I—3,400-3,500; II—2,600-2,700; III—1,800-1,900; and IV—1,100-1,200. The entire scale is presented in a folded insert. — D. B. V.

- 185-6. Starik, I. E. [Ye.]. *Yadernaya Geokhronologiya* [Nuclear geochronology]: Akad. Nauk SSSR, Moscow-Leningrad, 630 p., 1961.

An extensive and detailed summary of the nuclear methods of geologic age determination including much information of historical interest is presented in this book. The following topics are discussed: basic principles of radioactivity; uranium, thorium and lead; emanation; common lead; volumetric, isotope-dilution, and activation methods of argon analysis; determination of potassium by chemical and photometric methods; argon retention in minerals; rubidium and strontium; helium method; ionium method and ocean sediments; carbon-14 and its determination with proportional and liquid scintillation counters; summary of minor methods including discussions of osmium, rhenium, pleochroic haloes, uranium oxidation, beryllium-10, xenon from fission, calcium from potassium decay, radium in manganese nodules, disequilibrium in secondary uranium minerals, age of fossil bones, and age of oolites; the age of the earth and of meteorites; and a summary of geologic time scales including a new list of tie points from the U.S.S.R. A bibliography of almost 1,200 titles and exhaustive indices are provided. — H. F.

- 185-7. Bederke, E. *Kritische Betrachtung physikalischer Altersbestimmung* [Critical consideration of physical age determination]: Geol. Rundschau, v. 49, no. 1, p. 314-319, 1960.

Possible reasons for discrepancies between the absolute time scales of different authors, due to the limitations of various dating methods, are discussed. — D. B. V.

Fowler, William A., and Hoyle, F. Nuclear cosmochronology. See *Geophys. Abs.* 185-90.

Gourinard, Yves. On the presence of cosmic spherules in sedimentary rocks. See *Geophys. Abs.* 185-100.

- 185-8. Hedberg, Hollis D. *The stratigraphic panorama* (An inquiry into the bases for age determination and age classification of the earth's rock strata): Geol. Soc. America Bull., v. 72, no. 4, p. 499-518, 1961.

The basic purpose of chronostratigraphy is to interpret the history of the earth through the chronologic sequence of its strata. The principal means used to work out chronostratigraphy are the physical interrelations of strata,

the relation of strata to the sequence of organic evolution, and radioactive age determinations. Few of the supplementary lines of evidence can be proved to have had effects that were distinctly recognizable, identical in character, and synchronous over the whole world. Coordinated use of all possible lines of relative and absolute age determination and time correlation offers the best promise for continued progress in chronostratigraphy. The latter part of the paper concerns the related problem of chronostratigraphic classification. — D. B. V.

Ringwood, A. E. Changes in solar luminosity and some possible terrestrial consequences. See *Geophys. Abs.* 185-260.

- 185-9. Steiff, L[orin] R., and Stern, T[homas] W. Graphic and algebraic solutions of the discordant lead-uranium age problem: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 176-199, 1961.

The calculation of possible concordant ages from discordant lead isotope data has been greatly simplified by Wetherill's graphic method (see *Geophys. Abs.* 166-11). The linear relations noted in his procedure have been extended to plots of the mole ratios of total $Pb^{206}/U^{238}(N_{206}/N_{238})$ versus total $Pb^{207}/U^{235}(N_{207}/N_{235})$; this modification permits calculation of concordant ages for unaltered samples using only the Pb^{207}/Pb^{206} ratio of the contaminating common lead.

If isotopic data are available for two samples of the same age, x and y , from the same or related deposits or outcrops, graphs of the normalized difference ratios

$$\left[\frac{(N_{206}/N_{204})x - (N_{206}/N_{204})y}{(N_{238}/N_{204})x - (N_{238}/N_{204})y} \right] \text{ vs } \left[\frac{(N_{207}/N_{204})x - (N_{207}/N_{204})y}{(N_{235}/N_{204})x - (N_{235}/N_{204})y} \right]$$

can give concordant ages corrected for unknown amounts of a common lead with an unknown Pb^{207}/Pb^{206} ratio. Similar plots of the normalized difference ratios for three genetically related samples will give concordant ages corrected, in addition, for either one unknown period of past alteration or initial contamination by an older generation of radiogenic lead of unknown Pb^{207}/Pb^{206} ratio.

Algebraic equivalents of these new graphic methods give equations which maybe programmed for computing machines. For geologically probable parameters the equations of higher order have two positive real roots that rapidly converge on the exact concordant ages corrected for original radiogenic lead and for loss or gain of Pb or U. Modifications expanded only to the second degree have been derived for use with desk calculators. — D. B. V.

- 185-10. Davis, G. L., Tilton, G[eorge] R., Aldrich, L. T[homas], Wetherill, G[eorge] W., and Bass, M[anuel] N. The ages of rocks and minerals: *Carnegie Inst. Washington Year Book* 59, p. 147-158, 1960; reprinted in *Carnegie Inst. Washington Geophys. Lab. Ann. Rept. of Director* for 1959-60, 1960.

The various nuclear age-dating methods have established the role of long-term diffusion as a process leading toward discordant ages in rocks. The differential losses of Pb^{207} and Pb^{206} can be calculated for diffusion processes, and the predicted pattern of age discordances compared with those actually observed. Analyses of discordant age data from metamorphic zones in northern Michigan, from the Karelian basement complex in Finland, from the basement complex of the Appalachian orogenic belt in the Eastern United

States and Canada, and from the Canadian Shield are discussed, and it is concluded that long-term diffusion played an important role in causing discordant uranium-lead ages but is of less importance in determining the other age values. (See also *Geophys. Abs.* 185-2.)—V. S. N.

- 185-11. Picciotto, Edgar E. *Géochimie des éléments radioactifs dans l'océan et chronologie des sédiments océaniques* [Geochemistry of the radioactive elements in the ocean and chronology of the ocean sediments]: *Ciel et Terre*, v. 76, no. 3-4, p. 65-86, 1960.

The radioactive nuclides that occur naturally in the ocean are tritium, C^{14} , Be^{10} , K^{40} , U^{238} , Th^{230} (ionium), Rb^{87} , Ra^{226} , U^{235} , Pa^{231} , Th^{227} (radio-actinium), Th^{232} , Th^{228} (radiothorium), and Ra^{228} (mesothorium). Their concentrations are extremely low compared to those in the crust, and the Th/U ratio is particularly low (0.01 in the ocean compared to about 3 in rocks). All three radioactive families are out of equilibrium. Ra^{226} and Ra^{228} are in excess with respect to their parents, Th^{230} and Th^{232} . This situation offers interesting possibilities for tracer studies of ocean circulation.

The radioactive nuclides in pelagic sediments should show equilibrium deficiencies to complement the excesses in the water. The U and Th contents in pelagic clays have been found to be fairly constant and similar to those of granitic rocks. In young surface layers Th^{230} and Pa^{231} are definitely in excess with respect to uranium. Migration of Th^{230} -produced radium has been demonstrated. Th^{230} concentration decreases with depth in the sediment in a general way. Be^{10} has been reported in Pacific clays.

The dating methods based on these nuclides are reviewed briefly. C^{14} dates material up to the order to 25,000 yr old. Be^{10} is the sole hope at the moment of dating events that occurred 0.5-10X10⁶ yr ago. Th^{230} and Pa methods measure to 300,000 and 150,000 yr ago, respectively. Calculations can be made on the basis of the decrease of either element, in which case it is assumed that the uranium concentration in the ocean has remained constant with time; on the basis of the Th^{230}/Th^{232} ratio, with the assumption that the U/Th ratio has been constant; on the basis of the Pa^{231}/Th^{230} ratio, which is independent of variations in uranium content of the ocean; and on the basis of the Th^{230}/U^{238} and Pa^{231}/U^{235} ratios, where uranium has been separated from its descendants as in aragonite of coral reefs or oolites. The K-Ar and U-He methods can be applied to authigenic minerals or fossils in oceanic sediments. —D. B. V.

- 185-12. Starik, I. Ye., Starik, F. Ye., Petryayev, Ye. P., Lazarev, K. F., and Yelizarova, A. N. *Znachenie migratsii radioelementov iz mineralov dlya opredeleniya ikh vozrasta svinstovym metodom* [Significance of migration of radioactive elements from minerals for the determination of their age by the lead method (with English summary)]: *Internat. Geol. Cong.* 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 3, p. 15-31, 1960.

Discrepancies between ages determined from different lead isotope ratios are caused mainly by poor preservation of the sample; as a result of alteration various radioactive elements have migrated differently. Therefore, in order to evaluate these age determinations properly, it is necessary to study the migration behavior of all the radioelements as a function of such factors as acidity or the presence of other ions. The limiting value of leaching, which characterizes the portion of radioelements extracted from a mineral, together with the coefficient of emanation can serve as criteria for the suitability of a sample for dating purposes.

The limiting value of leaching of U, Ra, Rn, Pb²⁰⁶, and Pb²⁰⁷ is found to be greater than that for Th, Ra²²⁴, and Pb²⁰⁸ in monazite; therefore, the Pb²⁰⁸/Th²³² age is most probable in the case of monazite. The study of leaching from uraninite, on the other hand, suggests that the Pb²⁰⁶/U²³⁸, Pb²⁰⁷/Pb²⁰⁶, and Pb²⁰⁷/U²³⁵ ages are more reliable than the Pb²⁰⁸/Th²³² age. — D. B. V.

- 185-13. Narbutt, K. I., Laputina, I. P., Shuba, I. D., Kardakov, K. A., and Samoylov, G. P. *Isotopnyy sostav rudnogo svintsa i vozrast mineralov, soderzhashchikh U, Th i Pb, po mass-spektrometricheskim i rentgeno-spektral'nym dannym* [Isotopic composition of ore lead and the age of minerals containing U, Th, and Pb according to mass-spectrometer and X-ray data]: Akad. Nauk SSSR Inst. Geol. Rudnykh Mestorozhdeniy, Petrographii, Mineralologii i Geokhemii, Trudy, no. 28, p. 122-137, 1959.

Mass spectrometer isotopic analyses were made on the lead from 19 galena specimens and 8 radioactive minerals. The uranium, thorium, and lead contents of the radioactive minerals were determined by an X-ray-spectral method using the fluorescence spectrum. The accuracy of this method is ± 5 percent for concentrations of 1-80 percent of the element concerned, and is ± 10 percent for concentrations less than 1 percent.

The ages of the radioactive minerals were calculated on the basis of these analyses. The X-ray-spectral method is fully adequate for such minerals as monazite and uraninite but must be supplemented by mass spectrometer analysis of the lead for such minerals as pitchblende, brannerite, and samarskite. — J. W. C.

- 185-14. Houtermans, F. G. *Die Blei-Methoden der geologischen Altersbestimmung* [The lead methods of geologic age determination]: Geol. Rundschau, v. 49, no. 1, p. 168-196, 1960.

The principles of radioactive age determination in general and of the U-Pb, Th-Pb, Pb-Pb, RaD and ThB (Pb²¹⁰ and Pb²¹²), lead-alpha, and "common" lead methods in particular are reviewed. The chief results are discussed in the light of their bearing on the age of the earth and stoney meteorites and on geologic time scales. — D. B. V.

Russell, R[ichard] D., and Farquhar, R. M. Lead isotopes in geology. See Geophys. Abs. 185-393.

- 185-15. Hintenberger, H. *Die Rubidium-Strontium-Methode* [The rubidium-strontium method]: Geol. Rundschau, v. 49, no. 1, p. 197-224, 1960.

The principles and techniques of the Rb-Sr dating method are reviewed, and the results obtained on some suitable minerals from various parts of the world are presented. It is concluded that this method has attained at least the same degree of accuracy as the U-Pb and K-Ar methods. The results are enhanced when two or more independent radioactive methods are used on the same rocks. The reliability of the data is particularly high when U-Pb or Th-Pb determinations supplement Rb-Sr and K-Ar data; interesting conclusions concerning the history of a rock can be drawn from any discrepancies between the results. — D. B. V.

- 185-16. Erickson, G. P., and Kulp, J. L[aurence]. Potassium-argon measurements on the Palisades sill, New Jersey: Geol. Soc. America Bull., v. 72, no. 4, p. 649-652, 1961.

The $\text{Ar}^{40}/\text{K}^{40}$ ratios were determined for whole rock samples from different parts of the Palisades sill, for biotite separated from a concentration near the top of the sill, and for a sample from the first Watchung basalt flow. Comparison with the biotite, which is assumed to have retained all of its argon, shows that the fine and chilled phases of the sill retain all their argon, whereas the medium and coarse phases retain about 85 percent. These retentivities may be a function of mineral composition rather than mere texture. An argon retentivity of 40 percent is indicated for the Watchung basalt.

The results indicate that in some cases the argon retentivity of certain types of basaltic rocks may be as high as that of biotite. A study of the separate minerals in such rocks may support the application of the method to basalts in general. — D. B. V.

- 185-17. Fechtig, H., Gentner, W., and Zähringer, J. Argonbestimmung an Kaliummineralien—VII. Diffusionsverluste von Argon in Mineralien und ihre Auswirkung auf die Kalium-Argon-Altersbestimmung [Argon determination on potassium minerals, pt. 7. Diffusion loss of argon in minerals and its effect on the potassium-argon age determination (with English abstract)]: *Geochim. et Cosmochim. Acta*, v. 19, no. 1, p. 70-79, 1960.

Argon-37 was produced in calcium-containing minerals by means of a (n, α) reaction, and its diffusion measured as a function of temperature (T). Owing to the high sensitivity of the method it was possible to measure the diffusion constants (D) down to room temperature. For fluorite, anorthite, augite, and margarite the constants at room temperature are 10^{-21} - 10^{-25} cm^2 per sec. These results agree with those of K-Ar age determinations. The shape of the $D(1/T)$ curves shows two "knees" that account for discrepancies in values found by extrapolation. — D. B. V.

- 185-18. Zähringer, J. Altersbestimmung nach der K-Ar-Methode [Age determination by the K-Ar method]: *Geol. Rundschau*, v. 49, no. 1, p. 224-237, 1960.

The present state of the K-Ar dating method is reviewed. Decay constants, measuring techniques, and measurement error are discussed briefly, and the problem of argon diffusion and discrepancies between mica and feldspar ages are treated. It is concluded that the argon method is not the most accurate, but that it is practical and widely applicable and when used on micas can provide extremely useful geologic information. Results from some determinations on rocks and minerals from the Schwarzwald, Scandinavia, and the United States, and on iron meteorites are compiled. — D. B. V.

- 185-19. Afanas'yev, G. D., Kozhina, T. K., and Starik, I. Ye. Rezul'taty opredeleniya argonovym metodom vozrasta etalonnykh prob muskovita, biotita i mikrokлина [Results of age determinations of standard samples of muscovite, biotite and microcline by the argon method (with English summary)]: *Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3*, p. 9-14, 1960.

This paper is published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 3, p. 28-32, 1960 (see *Geophys. Abs.* 183-14). — D. B. V.

- 185-20. Plevaya, N. I., Murina, G. A., Sprintsson, V. D., and Kazakov, G. A. *Opredeleniya absolyutnogo vozrasta osadochnykh i vulkanogennykh formatsii* [Determination of the absolute age of sedimentary and volcanogenic formations (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 32-54, 1960.

The K-Ar ages of some intrusive and extrusive rocks and of glauconite from sediments representing a wide geographic and stratigraphic range in the U.S.S.R. and China are tabulated. It is shown that little argon is lost from glauconite, or from lava as it cools. The conclusion is drawn that volcanic rocks and glauconitic sediments can be dated reliably by the argon method. When these can also be dated in relation to formations of well established biostratigraphic age, their contribution to the establishment of an absolute geologic time scale will be considerable. — D. B. V.

- 185-21. Amirkhanov, Kh. I., Brandt, S. B., and Bartnitskiy, Ye. N. O metodike E. K. Gerlinga opredeleniya energii aktivatsii radiogennykh gazov v mineralakh [On E. K. Gerling's method of determining the activation energy of radiogenic gases in minerals]: *Geokhimiya*, no. 7, p. 646-649, 1960.

Gerling, E. K. Po povodu stat'i Kh. I. Amirkhanova, S. B. Brandta, i Ye. N. Bartnitskogo "O metodike E. K. Gerlinga opredeleniya energii aktivatsii radiogennykh gazov v mineralakh" [Apropos of the paper by Kh. I. Amirkhanov, S. B. Brandt, and Ye. N. Bartnitskiy "On E. K. Gerling's method of determining the activation energy of radiogenic gases in minerals"]: *ibid*, p. 649, 1960.

It is claimed that Gerling's work on the loss of radiogenic helium and argon from various minerals (see *Geophys. Abs.* 171-43, 183-13) is not compatible with modern theories of solids. Diffusion from a layer is examined mathematically, and it is shown that the activation energies are not characterized by the slopes of the logarithmic curves of the rate of liberation of radiogenic gases from minerals. Therefore, Gerling's values of activation energies, and the inferred differences in position of radiogenic atoms in the lattice, are completely arbitrary.

Gerling replies that the point of view of Amirkhanov and his colleagues is obsolete and not in accord with modern physical concepts on diffusion along a 'disturbed crystal lattice. Their use of a curve concerning argon liberation from different positions in the mineral, including an activation energy of zero, is mathematically absurd, as in that case argon could not be retained in the mineral. — D. B. V.

Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Significance of the argon-potassium ratio in ocean sediments. See *Geophys. Abs.* 185-590.

- 185-22. Münnich, K. O. Die C^{14} -Methode [The C^{14} method]: *Geol. Rundschau*, v. 49, no. 1, p. 237-244, 1960.

The principles, techniques, and sources of error of the radiocarbon dating method are reviewed briefly. The results and possibilities of the method are illustrated by a few typical examples. — D. B. V.

- 185-23. Olsson, Ingrid. The C^{14} dating stations using the CO_2 proportional counting method: *Arkiv Fysik*, v. 13, no. 3, p. 37-60, 1958.

After a discussion of the principles of radiocarbon dating and the occurrence of C^{14} in nature, the apparatus and procedure used at the Uppsala (Sweden) dating laboratory are described in full detail. — D. B. V.

National Bureau Standards. Redetermination of the half life of carbon-14. See Geophys. Abs. 185-488.

- 185-24. Daniels, Farrington. Kinetics and thermoluminescence in geochemistry: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 65-74, 1961.

This is the text of the presidential address delivered in 1958 before the Geochemical Society at St. Louis, Mo. After a brief survey of some branches of geochemistry, in which the helpful aspects of physical chemistry are mentioned, two special research fields are discussed in more detail: chemical kinetics, with application to the calcite-aragonite problem; and the thermoluminescence of crystals and its application to age determination. — D. B. V.

- 185-25. Ramdohr, P. Neue Beobachtungen an radioaktiven Höfen in verschiedenen Mineralien mit kritischen Bemerkungen zur Auswertung der Höfe zur Altersbestimmung [New observations on radioactive haloes in different minerals with critical remarks on the evaluation of haloes for age determination]: *Geol. Rundschau*, v. 49, no. 1, p. 253-263, 1960.

The method of age determination by means of pleochroic haloes is often applied to objects that are unsuitable for the purpose; this is true both of the radiating as well as of the discolored mineral. The sources of error lie in non-uniform size of the radioactive inclusions, in variations of activity within the granules (due to zonal structure), in the relative ages of the inclusions and host material, and in the exposure time and susceptibility to coloration of the host material. Age determinations by the pleochroic halo method therefore should be regarded with great caution. — D. B. V.

- 185-26. Ehmann, William D., and Huizenga, John R. A search for long-lived Ca^{50} and Cr^{56} : *Kentucky Acad. Sci. Trans.*, v. 21, no. 1-2, p. 1-5, 1960.

The existence of extinct natural radioactivity would have considerable significance in the fields of geochemistry and cosmology. An extinct natural radionuclide is one whose lifetime is too short for detectable amounts to be present from the time of nucleogenesis but is long enough to produce, through radioactive decay, effects that may be identified at present. Its half life falls in the range from 3×10^7 yr to 3×10^8 yr. Pb^{205} , Pu^{244} , and Cm^{247} appear to have half lives in this range. Of these only Pb^{205} with a stable decay product, Tl^{205} , would be important for isotopic dating.

The search made for the nuclides Ca^{50} and Cr^{56} by use of the active daughter extraction technique is described here. Results indicate a lower limit to the half life of Ca^{50} of approximately 1×10^3 yr and for Cr^{56} of approximately 1.1×10^4 yr if they are not both very short lived. The possibility that Ca^{50} and Cr^{56} might have half lives in the range for extinct natural radionuclides is not excluded by these results. Much longer irradiation times and larger, highly enriched samples must be used to extend the exclusion limits through this half life range. — V. S. N.

- 185-27. Toulmin, Priestly, 3d. Geological significance of lead-alpha and isotopic age determinations of "alkalic" rocks of New England: *Geol. Soc. America Bull.*, v. 72, no. 5, p. 775-780, 1961.

Recent age determinations indicate that at least two groups of "alkalic" igneous rocks exist in New England, with ages of about 185 and 270 million years. Because of their lithologic and geologic similarities, all these rocks had previously been grouped with the White Mountains plutonic-volcanic series of New Hampshire. Until reliable petrographic or geologic criteria become available for distinguishing these age groups, caution should be exercised in assigning any undated body of "alkalic" rock to one or the other group. — Author's abstract

- 185-28. Gilletti, Bruno J., and Damon, Paul E. Rubidium-strontium ages of some basement rocks from Arizona and northwestern Mexico: *Geol. Soc. America Bull.*, v. 72, no. 4, p. 639-643, 1961.

Results of 11 Rb-Sr age determinations on basement rocks from Arizona and northern Mexico are tabulated. The Precambrian age range is 1,200-1,500 $\times 10^6$ yr. The "1,350 million year orogeny" is extended into northwestern Arizona (Chloride granite) and southern Arizona (Oracle granite) near Tucson. Cretaceous-Tertiary ages were obtained for basement rocks in southern Arizona and northern Sonora, Mexico. — D. B. V.

- 185-29. Fairbairn, H[arold] W., Hurley, P[atrick] M., and Pinson, W[illiam] H. [Jr.]. Mineral and rock ages at Sudbury-Blind River, Ontario: *Geol. Assoc. Canada Proc.*, v. 12, p. 41-66, 1960.

The Sudbury-Blind River complex is a part of the area along the north shore of Lake Huron that is bounded by two more stable regions of contrasting age: on the north and northwest by granitic rocks and metasediments mostly 2.5-2.7 $\times 10^9$ yr old, and on the southeast by Grenville gneisses and granites 900-1,000 $\times 10^6$ yr old. The reconnaissance study reported here is part of a larger study to determine the degree to which each of the more stable shield areas has affected the isotopic ages within the north shore belt.

Eighty-three isotopic age analyses on biotite, potassium feldspar, and whole-rock samples from 45 localities were made by both K-Ar and Rb-Sr methods on igneous rocks and on a few metasediments. The dates obtained form an age spectrum from 1.0 to 2.2 billion years, and both K-Ar and Rb-Sr results give evidence of orogenic events at approximately 1.0, 1.2, and 1.6 billion years. Whole-rock analyses of igneous material, which show higher ages than do coexisting minerals, are believed to yield close approximations to the true age.

Data are summarized in tables and histograms, and a map shows the location of samples and the generalized geology of the Sudbury-Blind River area. — V. S. N.

- 185-30. Gross, G[ordon] A. Iron-formations and the Labrador geosyncline: *Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper* 60-30, 7 p., 1961.

The geology and structure of the Precambrian formations and associated iron-bearing members of the Labrador geosyncline are described briefly. Potassium-argon determinations on micas from 2 older Precambrian metamorphic units give ages of 2,365 $\times 10^6$ yr, and 1,635-1,935 $\times 10^6$ yr. Ages range from 440 to 1,580 $\times 10^6$ yr for younger Precambrian units within the geosyncline. — V. S. N.

- 185-31. Moor bath, S., Webster, R. K., and Morgan, J. W. Absolute age determination in south-west Greenland. The Julianehaab granite, the Ilímaussaq batholith and the Kûngnât syenite complex: [Denmark] Medd. om Grønland, v. 162, no. 9, p. 5-13, 1960.

Rubidium-strontium age measurements for the Julianehaab granite and for the Ilímaussaq batholith give values of $1,590 \pm 70 \times 10^6$ yr and $1,086 \pm 19 \times 10^6$ yr, respectively (using a value of 5.0×10^{10} yr for the half life of rubidium). These represent the maximum and minimum values for the age of the Gardar formation, which is thus Precambrian. The results furthermore show that the Ketilidian basement rocks (pre-Julianehaab granite) of southwest Greenland are themselves Precambrian. A Rb-Sr determination from the Kûngnât syenite complex also gives a Precambrian age ($1,240 \pm 150 \times 10^6$) indicating possible contemporaneity with the Ilímaussaq batholith. Two K-Ar age measurements are reported and are found to be in broad agreement with the Rb-Sr data. — Authors' abstract

- 185-32. Baadsgaard, H[alfdan], Folinsbee, R. E., and Lipson, J[oseph]. Potassium-argon dates of biotites from Cordilleran granites: Geol. Soc. America Bull., v. 72, no. 5, p. 689-701, 1961.

Biotites from 20 plutons of the North American Cordillera, mostly from British Columbia, have been dated by the K-Ar method. Most dates confirm geologic age interpretations. The Cordillera underwent 5 periods of granitic intrusion (in millions of years): Devonian (Acadian), 350-360; Early Mesozoic, 186 and 163; Middle Cretaceous (the major Cordilleran intrusion), 95-100; Late Cretaceous, 80; and Eocene (Rocky Mountain orogeny), 50-60. Small bodies intruded in the Cascade Range 18×10^6 yr ago (Miocene) are believed to be the youngest exposed batholiths in North America. — D. B. V.

- 185-33. Rouse, Glenn E., and Mathews, W. H. Radioactive dating of Tertiary plant-bearing deposits: Science, v. 133, no. 3458, p. 1079-1080, 1961.

Four K-Ar determinations from Tertiary rocks in the interior of British Columbia have yielded dates ranging from 45 to 49 million years. This suggests contemporaneity of three separate localities within the Middle Eocene epoch. Abundant plant micro- and macro-fossils support this conclusion and indicate a flora quite different from floras of comparable age in western United States. — Authors' abstract

- 185-34. Pittioni, Richard. Der Beitrag der Radiokarbon-Methode zur absoluten Datierung urzeitlicher Quellen. 2. Bericht [Contribution of the radiocarbon method to the absolute dating of primitive sites. 2d report]: Forschungen u. Fortschritte, v. 33, no. 7, p. 200-206, 1959.

This second compilation of radiocarbon data for Europe and North America lists results published since the first report (see Geophys. Abs. 172-3). Geologic and archeologic dates are given in separate tables, together with a bibliography of sources and an alphabetical list of sites. — D. B. V.

- 185-35. Shepard, Francis P. Rise of sea level along northwest Gulf of Mexico, in Recent sediments, northwest Gulf of Mexico: Tulsa, Okla., Am. Assoc. Petroleum Geologists, p. 338-344, 1960.

Carbon-14 determinations on nearshore and shallow-bay macro-organisms from the relatively stable Texas coast date the post-glacial rise of sea level from 300 feet below the present at 17,000 yr B. P. to about 40 feet at 8,000 B. P. The rise apparently has continued very slowly during most of the remaining time although unidentified fluctuations are possible. Fluctuations during the 17,000-8,000 B. P. interval, indicated by eastward-sloping drowned barriers, appear to correspond with some of the readvances of the continental ice sheets.

The history of rise along the Texas coast agrees with that along other stable coasts. Records from the Mississippi Delta area, however, indicate an independent subsidence of that area on the order of about 1 ft per century. A rapid downwarping in a portion of the Gulf Coast geosyncline is indicated rather than subsidence due solely to compaction of the delta sediments or to isostatic sinking under load. — V. S. N.

- 185-36. Rosholt, J[ohn] N., Emiliani, C[esare], Geiss, J[ohannes], Koczy, F[ritz] F., and Wangersky, P. J. Absolute dating of deep-sea cores by the $\text{Pa}^{231}/\text{Th}^{230}$ method: *Jour. Geology*, v. 69, no. 2, p. 162-185, 1961.

Dating by the $\text{Pa}^{231}/\text{Th}^{230}$ method of two deep-sea cores from the Caribbean separated by about 60 km has given a set of dates that are internally consistent, identical within the limits of error in stratigraphically equivalent levels of the two cores, and coincident with C^{14} chronology. These dates provide an absolute time scale from the present to about 175,000 yr ago. $\text{Pa}^{231}/\text{Th}^{230}$ and C^{14} measurements on deep-sea cores, C^{14} measurements on continental material, paleotemperature analysis of deep-sea cores, and correlation of the temperature record of the cores with continental events provide the following Pleistocene time scale: Postglacial, 0-10,000 yr; Late and Main Würm, 10,000-30,000 yr; Main Würm-Early Würm interval, 30,000-50,000 yr; Early Würm, 50,000-65,000 yr; Riss/Würm interglacial, 65,000-100,000 yr; Riss, 100,000-130,000 yr; and Mindel/Riss interglacial, 130,000-175,000 yr.

$\text{Pa}^{231}/\text{Th}^{230}$ dating of a deep-sea core from the North Atlantic gave ages consistently greater by 30,000 yr than dates from the Caribbean cores and the C^{14} chronology. This is believed to result from contamination by reworked clay. Sedimentation studies indicate that rates of sedimentation during the last 11,000 yr were lower than during previous time intervals. A generalized temperature curve, calibrated in terms of the C^{14} - $\text{Pa}^{231}/\text{Th}^{230}$ chronology, is presented. — V. S. N.

- 185-37. Koldewijn, B. W. Sediments of the Paria-Trinidad shelf [with Dutch summary]: *Amsterdam Univ. Fys.-Geog. Lab. Pubs.*, no. 1, 109 p., 1958.

Carbon-14 ages are reported for 13 samples taken from 9 sediment cores along the Paria-Trinidad shelf. The oldest plant remains dated were $17,820 \pm 600$ yr old. Estimates of the rate of deposition are made for various sites based on the carbon-14 dates and also on the thickness of the clay deposit. It is concluded that clay sedimentation started about 12,000 yr ago.

The relief and slope of the Paria-Trinidad shelf are factors of some influence in the deposition of the sediments. The most striking fact about this shelf is the extreme irregularity of the surface even though the steepest slopes hardly exceed one degree. The presence of three diverging orogenic belts in the vicinity, one of which is still active, supports the idea that the morphology of the shelf north of the Paria Peninsula and around Trinidad is strongly influenced by tectonics. — V. S. N.

- 185-38. Schreiner, G. D. L. Comparison of the $^{87}\text{Rb} \rightarrow ^{87}\text{Sr}$ ages of the red granite of the Bushveld complex from measurements on the total rock and separated mineral fractions: Royal Soc. [London] Proc., ser. A, v. 245, no. 1240, p. 112-117, 1958.

Rubidium-strontium age determinations were made on a portion of total crushed rock and on the feldspar fraction of each of four widely separated samples of the red granite of the Bushveld complex, and on biotite separated from one sample. These nine determinations yielded a mean age of 2.41×10^9 yr for a half life value of 6.3×10^9 yr, or 1.92×10^9 yr using a half life value of 5.0×10^9 yr. There are no variations between individual determinations that are significant at the 99 percent confidence level. For the unweighted mean age the 99 percent confidence limits are $\pm 0.13 \times 10^9$ yr. Despite the low enrichment of Sr^{87} the total rock method shows 99 percent confidence limits of $\pm 0.22 \times 10^9$ yr for the mean of four determinations. — D. B. V.

- 185-39. Allsopp, H. L. Rb-Sr age measurements on total rock and separated-mineral fractions from the Old Granite of the Central Transvaal: Jour. Geophys. Research, v. 66, no. 5, p. 1499-1508, 1961.

The ages of 5 total rock samples and 13 separated mineral fractions from granites and pegmatites of the Old Granite exposed between Johannesburg and Pretoria in the Transvaal were determined by the Rb-Sr method. The techniques employed are described briefly. The total-rock samples yield concordant results; the age of emplacement of the granite is found to be $3,200 \pm 65 \times 10^6$ yr and the primary abundance of Sr^{87} to be 0.07006 ± 0.00030 . The apparent ages deduced from the separated minerals differ widely, and are both higher and lower than the total-rock age. The discordance is considered to be due to diffusion of radiogenic strontium from mineral to mineral probably about $2,000 \times 10^6$ yr ago. — D. B. V.

- 185-40. Bésairie, H[enri]. Le socle cristallin de Madagascar [The crystalline basement of Madagascar], in *Asociacion de Servicios Geologicos Africanos: Internat. Geol. Cong., 20th, Mexico City, 1956*, p. 47-62, 1959.

The constitution of the metamorphic series and the different systems of the crystalline basement of Madagascar are described. The chronology is as follows: Androyan Graphite System, $2,600 \times 10^6$ yr; Vohibory System, $2,140 \times 10^6$ yr; magmatic epochs at 1,800, 1,660, 1,520 and $1,140 (\pm 350) \times 10^6$ yr; Cipolin Series and magmatism, $1,125 \times 10^6$ yr; magmatic epoch at 700×10^6 yr; many pegmatites, 485×10^6 yr; Quartzite Series (Devono-Carboniferous); and pre-Karoo orogenesis. (See also Geophys. Abs. 183-22.) — D. B. V.

- 185-41. Roubault, Marcel, and Durand, Georges L. Âges absolue de divers minéraux uranifères français déterminés par la méthode au plomb [Absolute ages of different French uranium minerals determined by the lead method]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 3, p. 367-370, 1961.

The ages of 4 pitchblendes, 1 gummite, and 1 pitchblende-gummite mixture from different parts of France and of 1 uranothorianite and 1 samirésite from Madagascar were determined by the lead method. Discordance of $\text{Pb}^{207}/\text{Pb}^{206}$ ages with respect to those calculated from the $\text{Pb}^{206}/\text{U}^{238}$ and $\text{Pb}^{207}/\text{U}^{235}$ ratios for the French pitchblendes and gummities shows that these minerals were formed $260 \pm 5 \times 10^6$ yr ago (Permian, terminal phase of the Hercynian orogeny) and were reworked $70 \pm 5 \times 10^6$ yr ago (beginning of the Alpine orogeny). — D. B. V.

- 185-42. Verger, Fernand, and Florschütz, Frans. Sur l'existence à Fromentine (Vendée) d'une couche de tourbe du début de l'atlantique [On the existence of a peat bed from the beginning of the Atlantic at Fromentine (Vendée)]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 6, p. 891-893, 1960.

Radiocarbon dating of a peat found 9.50 m deep in two borings at Fromentine, France, as $5,230 \pm 100$ yr B.C. confirms paleobotanic evidence that it was formed at the beginning of the Atlantic stage. — D. B. V.

- 185-43. Ferrara, G., Stauffer, H[einz], and Tongiorgi, E[zio]. Analisi isotopica del piombo in sedimenti uraniferi delle Alpi Orientali [Isotopic analysis of lead in uraniferous sediments of the East Alps]: Accad. Naz. Lincei Atti Cl. Sci. Fis., Mat. e Nat. Mem., Sess. 2, no. 2, p. 67-81, 1960.

The lead in samples from the continental "Val Gardena Sandstones" collected in the Val Rendena in the East Alps was analyzed isotopically. Results are tabulated and discussed.

Only two samples (silicified wood containing about 1 percent U) were suitable for age determinations by the RaD (Pb^{210}) method; these indicate an age of 220×10^6 yr for the original rock. Ages obtained on other samples suggest that secondary enrichment ($U > 10$ percent) occurred $70-95 \times 10^6$ yr ago. Comparison with results obtained in the West Alps suggests that the mobilization of heavy elements in the East Alps occurred at about the same time as in the Val d'Aosta, and that the uraniferous sediments of the East and West Alps could have been deposited contemporaneously. — D. B. V.

- 185-44. Brinkmann, R., Münnich, K. O., and Vogel, J. C. Anwendung der C^{14} -Methode auf Bodenbildung und Grundwasserkreislauf [Application of the C^{14} method to soil formation and ground water circulation]: Geol. Rundschau, v. 49, no. 1, p. 244-253, 1960.

The circulation of water in the ground can be followed closely by means of the carbon isotopes. Carbon-14 in particular makes it possible to understand better the formation of carbonate precipitations, and to determine the absolute age of calcareous crusts and of groundwater. Apparently, numerous calcareous crusts formed in the Mediterranean region during the Quaternary. Groundwaters yield ages up to 10,000 yr depending on their depth level. The significance of the method in the problem of cycles of juvenile-vadose water, deep groundwater, and fossil groundwater is indicated. — Authors' summary, D. B. V.

- 185-45. Watznauer, A. Bemerkungen zur physikalischen Altersbestimmung an sächsischen Graniten und Gneisen [Remarks on the physical age determination on granites and gneisses of Saxony]: Geol. Rundschau, v. 49, no. 1, p. 278-288, 1960.

For several years physical age determinations have been made in order to date more accurately the magmatic processes in the Saxon-Thuringian zone of the Variscan mountains. They concern the Lausitz granite complex, the Dohna granite, that of Karlsbad-Eibenstock and its mineral deposits, a number of Bohemian granites, and gneisses and schists from Saxony. The values given in tables and discussed in the text suggest that present physical methods of age determination are not yet unambiguous enough in the case of magmatic rocks to allow definite conclusions. The investigations are being continued. — Author's summary, D. B. V.

- 185-46. Neumann, Henrich. Apparent ages of Norwegian minerals and rocks: Norsk Geol. Tidsskr., v. 40, no. 3-4, p. 173-191, 1960.

Apparent ages determined on Norwegian rocks and minerals by different laboratories are compiled from various sources, including unpublished personal communications. Many recalculations are necessary in order to make the results mutually comparable and thus permit a more thorough and detailed analysis. However, these preliminary results clearly indicate that there were two important Precambrian epochs, one about $900-950 \times 10^6$ yr ago and the other about $1,100 \times 10^6$ yr ago. Surprisingly, there is as yet no evidence of the 1,400- and 1,800-million-year-old events that are so prominent elsewhere in the world. It is also noteworthy that the three Precambrian "formations" of southern Norway appear to have been formed by a number of penecontemporaneous and generally similar geologic events; differences in the resulting products depend mostly on variations in temperature and pressure and chemical environment. — D. B. V.

- 185-47. Magnusson, Nils H. Age determinations of Swedish Precambrian rocks: Geol. Fören. Stockholm Förh., v. 82, no. 4, p. 407-432, 1960.

The Precambrian history of Sweden is discussed in some detail in the light of the compiled results of available age determinations. Some 60 rocks have been dated by the K-Ar method, and 2 of these by the Rb-Sr method in addition. Seven samples were dated by two different potassium-argon laboratories in the U. S. S. R. The age data are tabulated.

The essential problems in the Swedish Precambrian are the regeneration processes and their effect on apparent ages. Many complementary determinations are necessary to elucidate details in different areas. — D. B. V.

- 185-48. Lundqvist, Glösta]. C14-Daterade tallstubar från fjällen [C¹⁴-dated pine stumps from the mountains (with English summary)]: Sveriges Geol. Undersökning, Årsb. 53, no. 3, (ser. C, no. 565), 21 p., 1959,

The results of radiocarbon dating of pine stumps from the mountains of western Sweden show that the pine immigrated soon after ice retreat, probably from the west. The oldest dated stumps are more than 4,000 yr old. The "fossil" timberline occurs at the intersection of the land uplift curve and the climatic curve; the effect of land uplift on the altitude of the timberline was greatest in the early stages and has decreased up to the present time. — D. B. V.

- 185-49. Krummenacher, Daniel, and Evernden, Jack F[oord]. Déterminations d'âge isotopique faites sur quelques roches des Alpes par la méthode Potassium-Argon [Isotopic age determinations made on some Alpine rocks by the potassium-argon method]: Schweitzer. Mineralog. Petrog. Mitt., v. 40, no. 2, p. 267-277, 1960.

Nine rocks from various parts of the Alps were dated by the K-Ar method on micas, and the results agree well with geologic data. The rocks of the Aiguilles-Rouges and Mount Blanc massifs yield ages that appear to be too young; this indicates loss of argon. The loss may be due to an accelerated rate of diffusion during hydrothermal and metamorphic activity of the Alpine orogeny. The size of the minerals used for dating appears to have an influence on the ages obtained; the diffusion of gas in the mineral is an inverse

function of grain size. The age found for the Grand-Paradis massif is somewhat older than that assigned to the Alpine orogeny. This is due either to the retention of radiogenic argon produced before the orogeny or to the Alpine orogeny being actually older than has been supposed. — J. W. C.

- 185-50. Gross, Hugo. Zur Frage der Gliederung und Chronologie der Letzten Eiszeit (Würm oder Weichsel) in Mitteleuropa [On the problem of the subdivision and chronology of the Last Glaciation (Würm or Weichsel) in central Europe]: *Forschungen u. Fortschritte*, v. 33, no. 11, p. 332-336, 1959.

The geologic and C^{14} data show that the short Würm chronology supported by Narr is false, and that the longer chronology, subdivided into three main intervals (Early Würm, Gottweig Interstadial, and Main Würm), is correct. — D. B. V.

- 185-51. Narr, Karl J. Nochmals: C^{14} -Daten und die Gliederung des Jungpleistozäns [Once more: C^{14} -dates and the subdivision of the late Pleistocene]: *Forschungen u. Fortschritte*, v. 34, no. 3, p. 90-91, 1960.

Gross' objections to Narr's subdivision of the late Pleistocene (see *Geophys. Abs.* 178-10, 185-50) are shown to be not well founded. — D. B. V.

- 185-52. Polkanov, A. A., and Gerling, E. K. Geokhronologiya dokembriya baltiyskogoschita [Geochronology of the Precambrian of the Baltic shield (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 57-82, 1960.

This paper has been published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 9, p. 183-191, 1960 (see *Geophys. Abs.* 183-31). — D. B. V.

- 185-53. Vinogradov, A. P., Komlev, L. V., Danilevich, S. I., Savonenkov, V. G., Tugarinov, A. I., and Filippov, M. S. Absolyutnaya geokhronologiya Ukrainskogo dokembriya [Absolute geochronology of the Ukrainian Precambrian (with English summary)]: *Internat. Geol. Cong.*, 21st., Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 83-111, 1960.

This paper has been published in English in the *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Proc.*, pt. 9, p. 116-132, 1960 (see *Geophys. Abs.* 183-35). — D. B. V.

- 185-54. Semenenko, N. P., Burkser, Ye. S., and Ivantishin, M. N. Vozrastnyye gruppy mineralizatsii porod Ukrainy v absolyutnom letoschislenii [Age groups of mineralization of rocks of the Ukraine in absolute age calculations (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov, Problema 3*, p. 112-131, 1960.

The evidence for each of the igneous and metamorphic cycles that have been established for the Ukrainian Precambrian on the basis of absolute age determinations (see *Geophys. Abs.* 183-34, and 184-44) is discussed. The lower boundary of the Cambrian is set at 570 million years. — D. B. V.

- 185-55. Vinogradov, A. P., Tugarinov, A. I., Knoore, K. G., Bibikova, Ye. V., and Lebedev, V. I. O vozraste kristallicheskogo osnovaniya Russkoy platformy [On the age of the crystalline basement of the Russian platform (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 132-148, 1960.

The results of absolute age determinations on cores from the crystalline basement underlying the thick Paleozoic-Mesozoic cover of the Russian platform show that the Voronezh massif in the region of the Kursk magnetic anomaly is about $1,800 \times 10^6$ yr old, the same as the ancient formations of the Baltic and Ukrainian shields. The next magmatic cycle, $1,600-1,700 \times 10^6$ yr old, is contemporaneous with the rapakivi intrusions of the southern Baltic shield and the intrusions in the Lower Proterozoic syncline between the Baltic and Ukrainian shields and the Voronezh massif. Intensive activity occurred in the area of the Pachelm depression and the Stalingrad slope of the Caspian depression about $1,400 \times 10^6$ yr ago, and the last Proterozoic cycle, about $900-1,100 \times 10^6$ yr ago, produced intrusions along the margins of the Baltic depressions and in the Volga region. The tectonic and magmatic activity of the Donets Basin, originating in the Early Proterozoic, was subsequently regenerated even as late as in Hercynian time. Recent tectonic movements in the Russian platform have occurred along ancient mobile zones that have been periodically reactivated throughout geologic history. — D. B. V.

- 185-56. Afanas'yev, G. D., Abdullayev, R. N., Bagdasaryan, G. P., Knorre, K. G., Rubinshteyn, M. M., and Studenikova, Z. V. Itogi geokhronologicheskikh issledovaniya magmaticheskikh gornykh porod Kavkaza [Results of geochronological investigations of magmatic rocks of the Caucasus (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 161-194, 1960.

The results of argon age determinations made on igneous and a few metamorphic rocks from different structural units of the Caucasus are compiled and the geologic history of the region inferred from the results. The significance of discrepancies between the ages of micas and alkali feldspars from the same specimens is discussed. — D. B. V.

- 185-57. Ovchinnikov, L. N., and Garriss [Harris], M. A. Absolyutnyy vozrast geologicheskikh obrazovaniy Urala i Priural'ya [Absolute age of geologic formations of the Urals and Pri-Urals (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 195-207, 1960.

The English version of this paper has been published in the Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 3, p. 33-45, 1960 (see Geophys. Abs. 183-39). — D. B. V.

- 185-58. Komlev, L. V. Absolyutnyy vozrast granitnykh intruziy tsentral'nogo i severnogo Kazakhstana i shkala geologicheskogo vremeni [The absolute age of the granitic intrusions of central and northern Kazakhstan and the geologic time scale (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 208-221, 1960.

On the basis of absolute age determinations by different methods on granitic rocks from northern and central Kazakh S.S.R., the following time scale is established (in millions of years): end of the Paleozoic, 260; Permian-Car-

boniferous boundary, 300; end of the Viséan (Middle Carboniferous), 360; Early Devonian, 420; end of Middle Ordovician, 500; early Caledonian cycle, 500-?; late Caledonian cycle, 420-480; early Hercynian cycle, 340-380; and late Hercynian cycle, 260-320. — D. B. V.

- 185-59. Semenov, A. I., and Shuvalov, Yu. M. O vozraste Kryk-Kudukstoy intruzii v severnom Kazakhstane [On the age of the Kryk-Kuduk intrusion in northern Kazakhstan]: Akad. Nauk SSSR Doklady, v. 137, no. 2, p. 397-399, 1961.

The age of the Kryk-Kuduk intrusive massif in northern Kazakh S.S.R. has been established on the basis of field relations, degree of metamorphism, and K-Ar dating (500×10^6 yr) as middle Llandeilan or older. — D. B. V.

- 185-60. Semenenko, M. P. [N. P.], and Tsarovskiy, I. D. Zfstavlennyya heoloho-strukturnykh danykh z rezul'tatamy vyznachennyya absolyutnoho viku luzhnykh porid Pryazov'ya [Comparison of geologic-structural data with the results of absolute age determinations on the alkaline rocks of the Azov region (with Russian summary)]: Akad. Nauk Ukrain. R. S. R. Heol. Zhur., v. 19, no. 6, p. 3-11, 1959.

The alkaline rocks of the Azov region of the Ukrainian S. S. R. occur structurally as centers with radial systems of metasomatically alkalized silicic rocks and as linear bodies related to fracture systems. Potassium-argon determinations show that these structures are not contemporaneous, the former giving ages of $800-1,260 \times 10^6$ yr and the latter of $250-280 \times 10^6$ yr. — D. B. V.

- 185-61. Khamrabayev, I. Kh. Ob absolyutnom vozraste granitoidnykh intruzivov i postmagmaticheskikh obrazovaniy Zapadnogo Uzbekistana [Absolute age of granitic intrusives and postmagmatic deposits of western Uzbekistan]: Akad. Nauk Uzbek. SSR, Izv., Ser. Geol., no. 1, p. 77-87, 1957.

The granitic intrusions and postmagmatic ore deposits of western Uzbek S. S. R. are geologically older than the Middle Carboniferous and younger than the Upper Carboniferous-Permian continental deposits. The most reliable absolute age for both the granites and ore deposits is 180-200 million years, which corresponds to the end of the Carboniferous and the beginning of the Permian. Contemporaneity of igneous activity and mineralization is thus demonstrated. None of the age methods was successful in distinguishing individual phases of intrusion. This is explained by the interval between phases being less than 1 million years, which lies below the threshold of accuracy of the methods. The discrepancy between the geologic age and the absolute age may be caused by imperfections in the argon method and by inaccurate geologic dating. — J. W. C.

- 185-62. Krylov, A. Ya. Absolyutnyy vozrast porod tsentral'nogo Tyan'-Shanya i primeneniye argonovogo metoda k metamorficheskim i osadochnym porodam [Absolute age of rocks of the central Tien Shan and application of the argon method to metamorphic and sedimentary rocks (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 222-244, 1960.

Total rock age determinations were made on a wide range of rocks from the central Tien Shan by the argon method. Three cycles are distinguished on the

basis of 62 samples of granitic rocks (in millions of years): Proterozoic, 540; Caledonian (the most important), 370; and Hercynian, 280. The volcanic rocks represent three cycles: Caledonian, Hercynian, and a Tertiary cycle 55 million years ago. The last metamorphism was Caledonian.

During decomposition of granitic rocks, the Ar/K ratio changes in two stages. Argon is lost before potassium, but the difference disappears in the final weathered products. Study of the retention of argon in granitic gravel, sands, sandstones, clays, and silts showed that the proportion of radiogenic argon is generally the same as in the original feldspar. Therefore, the argon method may be used to estimate the age of the source material of clastic sediments and thus to solve several paleogeographic problems, such as the dispersal of glacial material from Fennoscandia and the source of terrigenous deposits carried to the Black Sea (see Geophys. Abs. 176-14, 181-50, 182-12). — D. B. V.

- 185-63. Krylov, A. Ya., and Silin, Yu. I. Vremya metamorfizma drevnykh otlozheniy severnoy zony Tyan'-Shanya [Time of metamorphism of the old sediments of the northern zone of the Tien Shan]: Akad. Nauk SSSR Doklady, v. 122, no. 5, p. 889-891, 1958.

Results of argon age determinations on 36 metasedimentary rocks from the Proterozoic and Lower Paleozoic of the northern zone of the Tien Shan and on 2 from the Lower Paleozoic of the southern zone are tabulated. The metamorphism apparently is Caledonian ($330-360 \times 10^6$ yr) in the northern Tien Shan; there are no perceptible Hercynian and Alpine metamorphic effects. The samples from the southern Tien Shan, on the other hand, were metamorphosed $280-295 \times 10^6$ yr ago, in the Hercynian. — D. B. V.

- 185-64. Krylov, A. Ya., Silin, Yu. I., and Lovtsyus, A. V. Vozrast granitoidov severnoy zony Tyan'-Shanya [Age of granites of the north zone of Tien Shan]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy, 7th sess., p. 197-204, 1958 (1960).

Sixty absolute ages of granites of the northern and central Tien Shan are reported. The principal cycles of intrusion were Proterozoic at $465-560 \times 10^6$ yr, Caledonian at $310-385 \times 10^6$ yr, and Hercynian at $240-280 \times 10^6$ yr. — A. J. S.

- 185-65. Bykovskaya, Ye. V., and Polevaya, N. I. Absolyutnyy vozrast vulkanogennykh obrazovaniy Badzhal'skogo i Bureinskogo khrebtov [Absolute age of volcanogenic formations of the Badzhal' and Burein ranges]: Akad. Nauk SSSR Izv. Ser. Geol., no. 10, p. 86-91, 1960.

The results of K-Ar age determinations on 12 samples of igneous rocks from the Upper Burein region (Badzhal' and Burein ranges) in Siberia are tabulated. The ages range from 75 million years (Late Cretaceous) to 193 million years (Triassic) and are consistent with the stratigraphic evidence. The consistency of results in the case of a granite 86 million years old which intrudes a liparite-dacite 93 million years old and is in turn overlain by a vitroliparite 75 million years old is significant; evidently argon loss has been negligible in both the intrusive and extrusive rocks. Although K-Ar data cannot yet be used as a basis for stratigraphic subdivision, igneous masses can definitely be correlated by this method. — D. B. V.

- 185-66. Krasnyy, L. I., and Polevaya, N. I. Absolyutniy vozrast nekotorykh magmaticheskikh porod Dal'nego Vostoka [Absolute age of some magmatic rocks of the Far East (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 3, p. 245-251, 1960.

Results of argon age determinations on igneous rocks from the Far Eastern Region of the U. S. S. R. (Amur, Khabarovsk) show that the Stanovoy-Dzhugdzur Proterozoic folded region on the southeast edge of the Aldan shield has been intruded by large granite bodies up to late Mesozoic time. In the Mongol-Okhotsk folded region, where a geosyncline was present mainly in Paleozoic and Mesozoic time, the intrusions are early and late Paleozoic and Mesozoic in age. In the Sikhote Alin young folded region, a geosyncline was present from late Paleozoic to Paleogene time. A preliminary regional time scale for the area is given in a chart. — D. B. V.

- 185-67. Mahadevan, C., Sastry, A. V. R., and Aswathanarayana, U. Some aspects of nuclear geology in India: Pan Indian Ocean Sci. Cong., 3d, Tananarive, Proc., Sec. C, p. 33-37, 1957 (1960).

Available age data indicate orogenic cycles in India at $2,300 \pm 100$, $1,625 \pm 75$, $1,300 \pm 150$, 955 ± 40 , and 735 ± 5 million years. The distribution of radioactivity has also been studied for various rock types and for modern marine sediments off the east coast. — J. W. C.

- 185-68. Katsui, Yoshio, and Murase, Tsutomu. Some considerations on the activity of the Shikotsu Volcano [in Japanese with English abstract]: Geol. Soc. Japan Jour., v. 66, no. 781, p. 631-638, 1960.

Carbon-14 dating of carbonized trunks of *Picea jezoensis* found buried in pumice deposits places the formation of Shikotsu caldera, southwest Hokkaido, Japan, at 20,000 yr ago. Field study of the caldera and associated pumice deposits indicates that the eruption forming the caldera resembled the 1883 eruption of Krakatau, although on a larger scale. — V. S. N.

- 185-69. Hurley, P[atrick] M., Fisher, N. H., Pinson, W[illiam] H., Jr., and Fairbairn, H[arold] W. Geochronology of Proterozoic granites in Northern Territory, Australia. Pt. 1: K-Ar and Rb-Sr age determinations: Geol. Soc. America Bull., v. 72, no. 5, p. 653-662, 1961.

K-Ar and Rb-Sr age measurements on granitic rocks intrusive into two subdivisions of the Lower Proterozoic in Northern Territory, Australia, show well grouped ages averaging $1,440 \times 10^6$ yr and $1,630 \times 10^6$ yr. The geologic evidence as well as the concordance between the Rb-Sr and K-Ar measurements suggest that these are close to the true values, marking the end of two disturbances which produced intracratonic basins of sedimentation. — D. B. V.

- 185-70. Walpole, B. P., and Smith, K. G. Geochronology of Proterozoic granites in Northern Territory, Australia. Pt. 2: Stratigraphy and structure: Geol. Soc. America Bull., v. 72, no. 5, p. 663-668, 1961.

The stratigraphy and structure of the Precambrian rocks of Northern Territory, Australia, are summarized in the light of the age determinations reported in the first part of this report (see Geophys. Abs. 185-69). The older group of granites marks the top of the lower subdivision of the Lower Proterozoic and the younger group marks the top of the Lower Proterozoic. — D. B. V.

- 185-71. Russell, R[ichard] D., Ulrych, T. J., and Kollar, F. Anomalous leads from Broken Hill, Australia: Jour. Geophys. Research, v. 66, no. 5, p. 1495-1498, 1961.

Seven Thackaringa-type leads from veins at Broken Hill, Australia, have been analyzed isotopically. The points representing these leads lie along a straight line on a Pb^{207}/Pb^{204} versus Pb^{206}/Pb^{204} plot, proving beyond serious doubt that these are anomalous leads. The isotopic analyses indicate that these leads were deposited not earlier than $1,190 \pm 50 \times 10^6$ yr ago and that the source material for the anomalous radiogenic lead component came into existence not before $1,970 \pm 50 \times 10^6$ yr ago but not later than $1,190 \pm 35 \times 10^6$ yr ago. Approximate values for the Th/U ratios of the anomalous lead sources are included. — D. B. V.

- 185-72. Wilson, Allan F., Compston, W., Jeffery, P. M., and Riley, G. H. Radioactive ages from the Precambrian rocks in Australia: *Geol. Soc. Australia Jour.*, v. 6, pt. 2, p. 179-195, 1960.

The oldest rocks of the Australian Precambrian basement occur in Western Australia where huge tracts of granitic rocks have been dated at about 2,700 million years by the Rb-Sr and K-Ar methods. They also show metamorphism at 2,400 million years. This shield area is flanked and cut by younger Precambrian rocks—on the southeastern side by pegmatized basic charnockites, 1,300 million years; on the southern side by rocks pegmatized at 1,400 million years; and on the west by rocks showing regional magmatic activity at 900-1,100 million years and vigorous recrystallization at about 650 million years. A long east-west 1,000 million year belt in central Australia may continue westward to divide the central nucleus of the shield. Granites in northern Australia are at least 1,650 million years old with uranium mineralization at 500 million years, and in South Australia periods of uranium mineralization at 500 and 1,500 million years are recognized. Major age divisions in Canada and Australia appear to be closely comparable. — V. S. N.

- 185-73. Gage, Maxwell. New Zealand glaciations and the duration of the Pleistocene: *Jour. Glaciology*, v. 3, no. 29, p. 940-943, 1961.

Recent work in New Zealand has resulted in recognition of an additional glaciation preceding the Waimea glaciation in the late Pleistocene. This new period followed the mid-Pleistocene climax of the earth movements responsible for most of the present mountainous relief of New Zealand and an interval of time long enough for the construction and subsequent deep dissection of the Banks Peninsula shield volcano. This suggests an interval of several hundred thousand years between the earliest late Pleistocene glaciation and the early Pleistocene Ross glaciation and a length of at least one million years for the entire Pleistocene period. This estimate for the Pleistocene does not fit well with the datings of major climatic conditions based on carbon-14, radium/ium, and oceanic sedimentation rates. — V. S. N.

- 185-74. Nicolaysen, L. O., Burger, A. J., Tatsumi, T., and Ahrens, L[ouis] H. Age measurements on pegmatites and a basic charnockite lens occurring near Lützow-Holm Bay, Antarctica: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 94-98, 1961.

Rb⁸⁷-Sr⁸⁷ age measurements were carried out on large biotite crystals from 3 granitic pegmatites and a basic charnockite lens occurring near Lützow-Holm Bay, Queen Maud Land. The mean age obtained (~515 million years) probably refers to the last major metamorphic episode in this region. The age data are also significant for the interpretation of paleomagnetic results reported from this area. — Authors' abstract

- 185-75. Starik, I. Ye., Krylov, A. Ya., Ravich, M. G., and Silin, Yu. I. *Vozrast gornykh porod vostochnoy Antarktity* [The age of rocks from eastern Antarctica (with English summary)]; *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 3, p. 149-157, 1960.

Absolute ages determined by the argon method for 80 samples of granitic and metamorphic rocks collected in eastern Antarctica in 1956-58 are tabulated. The decay constants used were $\lambda_K = 5.57 \times 10^{-11} \text{yr}^{-1}$, $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$. The rocks fall into eight age groups (in millions of years): Tertiary, 20; Mesozoic, 185; middle Paleozoic, 335; early Paleozoic, 460; late Proterozoic, 585; middle Proterozoic, 735; early Proterozoic, 1,090; and late Archean, 1,440. The last regional metamorphism was in the early Paleozoic. The oldest rocks yet found are the granites of the Langenesset oasis, 1,525 million years old. This is the first attempt to subdivide East Antarctic rocks chronologically. (See also *Geophys. Abs.* 177-20, 183-46.)—D. B. V.

Stauffer, Heinz. Cosmogenic argon and neon in stone meteorites. See *Geophys. Abs.* 185-94.

Goles, Gordon G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system. See *Geophys. Abs.* 185-91.

Wänke, H. Exposure ages for iron meteorites. See *Geophys. Abs.* 185-93.

Marshall, Royal R., and Hess, David C. Lead from some stone meteorites. See *Geophys. Abs.* 185-86.

COSMOGONY

- 185-76. Krinov, E. L. *Principles of meteoritics*: London, Pergamon Press Inc., 535 p., 1960.

This book is a translation of the original Russian edition published in 1955(?) that has been checked and brought up to date by Professor Krinov. The aim of the volume is to present the principles underlying meteoritics and to point out the most important problems confronting the science. The text includes eight chapters as follows: meteoritics as a branch of science, motion and fall of meteorites, morphology of meteorites, chemistry of meteorites, mineralogy and petrography of meteorites, physical properties of meteorites, tektites and silica-glass, and the origin of meteorites. A catalogue of meteorites of the U. S. S. R. as of January 1, 1959, a list of meteorites of rare type, and a classification of surface structure of fusion crusts of meteorites are given in three appendices. A reference list of 207 citations is included. — V. S. N.

- 185-77. Krinov, E. L. The nature of micrometeorites: *Am. Jour. Sci.*, v. 259, no. 5, p. 391-395, 1961.

Meteorite showers are due to the fragmentation of one large meteorite during its movement through our atmosphere at cosmic velocity and not to the invasion of our atmosphere by swarms of meteoritic bodies as formerly believed. Included in the material resulting from such a break-up are entire clouds of microscopic dustlike fragments that fall on the earth as individual samples of meteorite showers. These minute fragments have the fusion crust and morphological properties of meteorites in general. They differ from cosmic dust in that the cosmic dust particles are practically unaltered by impact with our atmosphere. — V. S. N.

- 185-78. Brown, Harrison. Addendum: The density and mass distribution of meteoritic bodies in the neighborhood of the earth's orbit: Jour. Geophys. Research, v. 66, no. 4, p. 1316-1317, 1961.

The total rate of fall upon the earth appears to be about 560 meteorites per year. All of the computed impact frequencies of meteorites upon the earth and moon, given in an earlier paper (see Geophys. Abs. 182-61) should be multiplied by a factor of 3.4. — D. B. V.

- 185-79. Fisher, David E. Space erosion of the Grant meteorite: Jour. Geophys. Research, v. 66, no. 5, p. 1509-1511, 1961.

An upper limit to the erosion of iron meteorites in space is calculated, based on the cosmic exposure age of the Grant meteorite and the measured depth variation of cosmogenic Ne^{21} in this meteorite. A value for E_{max} of $\sim 1.1 \times 10^{-8}$ cm per yr is found. A previous estimate based on the Sikhote-Alin meteorite is discussed. — Author's abstract

- 185-80. Urey, Harold C. Criticism of Dr. B. Mason's paper on "The origin of meteorites": Jour. Geophys. Research, v. 66, no. 6, p. 1988-1991, 1961.

The simple outline of events proposed by Mason (see Geophys. Abs. 181-53) to explain the origin of chondrites cannot be correct; much more complicated histories are required. Simple heating of carbonaceous chondrites will not produce the metal structures of the chondritic meteorites. Mason also suggested that chondrites were always small bodies. It seems probable, however, that only objects at least as large as asteroids could be heated to high temperatures with the escape of appreciable amounts of volatiles and still remain as celestial bodies; nor has any physically possible source of the heat needed for heating small objects yet been suggested.

Misunderstandings of this problem are due to the fact that geologists and geochemists deal essentially with an open system in the case of terrestrial rocks. The variability in composition of all the classes of meteorites makes it difficult to conclude definitely whether they are adequate samples of a closed system. Urey assumes that the planets are not a closed system because of their variable densities, and that the chondritic meteorites are only an approximate sample of primordial matter. — D. B. V.

- 185-81. Stacey, F. D., Lovering, J. F., and Parry, L. G. Thermomagnetic properties, natural magnetic moments, and magnetic anisotropies of some chondritic meteorites: Jour. Geophys. Research, v. 66, no. 5, p. 1523-1534, 1961.

Thermomagnetic analyses, thermal demagnetization of natural and laboratory-induced remanent magnetic moments, and measurements of magnetic anisotropy have been carried out on a number of chondritic stone meteorites. Alpha-phase iron-nickel (kamacite) containing 5-6 percent Ni was found to be responsible for 80-90 percent of the saturation magnetic moments and for most of the observed remanence and magnetic anisotropy. The natural magnetic moments of the Mount Browne, Homestead, and Farmington chondrites had two components of quite different origins; in each case the important component appears to have been induced thermally in an extraterrestrial field. The Mokoia carbonaceous chondrite had only a small moment, consistent with isothermal induction in the earth's field. The magnetic anisotropies of eight chondrites were related to the degree of metamorphism indicated by their porosities.

The magnetic evidence is consistent with the supposition that the chondrites once formed parts of the mantle of a body with a fluid metal core which produced a magnetic field of terrestrial type. — D. B. V.

- 185-82. Honda, M[asatake], Shedlovsky, J. P., and Arnold, J[ames] R. Radioactive species produced by cosmic rays in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 133-154, 1961.

The radioactive isotopes Be^{10} , Al^{26} , Cl^{36} , K^{40} , and Mn^{53} have been measured in the Grant, Williamstown, Odessa, and Canyon Diablo iron meteorites. Each sample was recycled to constant activity, using a different chemistry for each recycle wherever possible. The samples were counted with a low-level β -counter, except for Mn^{53} for which X-rays were measured. These samples are probably the first sources of Mn^{53} that have been counted. Results are tabulated.

Except for Mn^{53} where a depth effect is apparent, the isotope ratios were approximately constant for each meteorite. The cosmic-ray age, depth effect, and time variation of cosmic-ray intensity will be discussed in a subsequent paper. — D. B. V.

- 185-83. Sheline, R. K., and Hooper, J. E. Probable existence of radioactive manganese-53 in iron meteorites: *Nature*, v. 179, no. 4550, p. 85-87, 1957.

Sheline and Hooper believe that the half life of Mn^{53} is much longer than previously thought, and that the amount of Mn^{53} activity produced in iron meteorites exposed to cosmic ray fluxes in solar space for a million years or more within the past few million years should be easily detectable. The search for Mn^{53} in meteorites at the very least would give additional information on cosmic-ray intensity in solar space. If activity is found, the determination of its intensity in concentric shells as a function of depth should yield information on the intensity of low-energy cosmic radiation within the solar system. If certain problems can be overcome it should be possible to date the fall of meteorites by their Mn^{53} content; such dating could presumably go back several million years.

The relative amounts of H^3 and Mn^{53} in recently fallen meteorites should tell something about the constancy of cosmic-ray intensity over periods of about one million years. Finally, if appreciable amounts of Mn^{53} could be found on the earth's surface (the possibility of its accumulation in the polar regions has been suggested), it might constitute an important tool with which to date the time of burial of terrains back to a few million years. — D. B. V.

- 185-84. Feller-Kniepmeier, M., and Uhlig, H. H. Nickel analyses of metallic meteorites by the electron-probe microanalyzer: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 257-265, 1961.

Nickel analyses of separate phases in 9 metallic and 1 stone meteorite were obtained by means of the electron-probe microanalyzer. The composition was uniform throughout the kamacite phase; however, the nickel content was appreciably lower near a schreibersite inclusion. Taenite showed a marked composition gradient which increased at the taenite-kamacite interface. The nickel content of fine plessite was intermediate; it also showed a concentration gradient that was continuous with that of adjacent taenite.

These results are in agreement with slow cooling of the original body or bodies to a temperature of 300°C or lower during a long period of time; however, the time was short of that required to produce a uniform composition for taenite or for kamacite near schreibersite inclusions. — D. B. V.

- 185-85. Reed, G[eorge] W., Kigoshi, K., and Turkevich, A[nthony]. Determinations of the concentrations of heavy elements in meteorites by activation analysis: *Geochim. et Cosmochim. Acta*, v. 20, no. 2, p. 122-140, 1960.

Barium, mercury, thallium, lead, bismuth, and uranium contents and isotopic compositions of some stone meteorites and of the troilite phase of iron meteorites have been determined by neutron activation analysis. Two groups of chondrites were observed. The group including the enstatite and carbonaceous chondrites has orders of magnitude more of the chalcophilic elements studied than do the other chondrites. Barium and uranium do not show this variation. The lead in this group is primordial in its Pb^{208}/Pb^{204} isotopic composition, as might be expected from the Pb/U ratio. Some of the nuclear and geochemical implications of these results are suggested.

The Nuevo Laredo meteorite is interesting because it is the only one in which the absolute amounts of lead, thorium, and uranium are consistent with an observed isotopic composition of the lead (see *Geophys. Abs.* 157-131). The age of 4.5×10^9 yr that has been deduced for it is probably trustworthy; in other meteorites for which lead-lead ages have been quoted there is a question whether there is enough uranium and thorium to be compatible with the amount of the radiogenic lead, and the ages must be considered suspect. The Bi^{209} content of Nuevo Laredo also gives a lower limit of 1.6×10^7 yr for the time that must have elapsed since the formation of the elements and their segregation into the matter that forms the meteorite. This lower limit is shorter than the $>4 \times 10^8$ yr deduced from the Xe^{129} content (see *Geophys. Abs.* 163-150, 171-8) but may be more reliable as it does not depend on the retention of a noble gas. — D. B. V.

- 185-86. Marshall, Royal R., and Hess, David C. Lead from some stone meteorites: *Jour. Chem. Physics*, v. 28, no. 6, p. 1258-1259, 1958.

The isotopic composition of lead (extracted by a volatilization process) from two stone meteorites was determined. For the Richardton chondrite, $Pb^{206}/Pb^{204}=27.57$, $Pb^{207}/Pb^{204}=22.13$, and $Pb^{208}/Pb^{204}=48.51$; for the Holbrook chondrite the corresponding ratios are 17.52, 15.52, and 38.93, respectively. The Richardton lead is considerably more radiogenic than terrestrial lead. In Holbrook the U/Pb ratio is lower than that of crustal lead, and thorium is relatively higher. The lead-lead ages deduced from these isotopic compositions are both 4.7×10^9 yr, agreeing within the limits of error with other investigations.

Although the amount of lead present is not more than a few tenths of a ppm, it is 1.5-3 times as much as it should be according to the measured uranium concentrations; this relative excess of lead may be characteristic of stone meteorites. — D. B. V.

- 185-87. Hess, D[avid] C., and Marshall, R[oyal] R. The isotopic compositions and concentrations of lead in some chondritic stone meteorites: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 284-299, 1960.

The isotopic compositions of lead from the Richardton, Holbrook, Beardsley, and Plainview chondrites have been analyzed. The technique used is described. The isotopic compositions were found to range from highly radiogenic (in Richardton) to substantially less radiogenic than average lead in the earth's crust (in the other three). From recent concentration determinations

by the isotopic dilution method, it seems that the amount of lead in Beardsley is about 0.13 ppm and in Richardton about 0.06 ppm. The leads in these meteorites are consistent within a factor of about 2 with the lead-lead ages and the independently measured uranium and thorium concentrations. The lead-lead age for Richardton is the same as that found by Patterson for Nuevo Laredo (see *Geophys. Abs.* 167-5), 4.6×10^9 yr. The lead concentration in Forest City is 0.09 ppm, while that in Holbrook is 0.28 ppm. Holbrook is quite anomalous in containing 2.5 times more radiogenic lead than can be explained by the accumulation of decay products in place. The total amount of lead on the surface of a meteorite appears to be comparable to the total amount inside. The isotopic composition of this surface lead indicates that it is principally terrestrial lead. — D. B. V.

- 185-88. Marshall, R[oyal] R., and Hess, D[avid] C. Lead from troilite of the Toluca iron meteorite: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 161-164, 1961.

The isotopic composition of silver from troilite of the Toluca (Xiquipilco) iron meteorite was found in 1957 (see *Geophys. Abs.* 185-89) to be similar to that of terrestrial silver; lead from the same sample was found to be different from the primeval lead observed by Patterson and others (see *Geophys. Abs.* 160-144 and 162-171) in the Canyon Diablo and Henbury iron meteorites. The simplest explanation of the fact that the Toluca troilite lead is nearly as radiogenic as average modern lead at the earth's surface is that this troilite may contain uranium and thorium. Assuming that the original lead isotopic composition was the same as that of Patterson's primeval lead, the lead-lead age of the meteorite would be about 4.7×10^9 yr, about the same as that of the stone meteorites.

Should analyses reveal only very small concentrations of uranium and thorium in the Toluca troilite, however, the latter would be similar to the Holbrook chondrite in having a peculiar excess of radiogenic lead (see *Geophys. Abs.* 185-86, -87). In that event another possible explanation would be the addition of lead more recently than 4.7×10^9 yr ago. A model age of 0.77×10^9 yr is calculated on this assumption. If the iron meteorite formed only about 10^9 yr ago, variation in the isotopic composition of silver would be quite unlikely.

Although the concentration and isotopic composition of the lead reported here need not be characteristic of all or even most of Toluca, it may be an important clue to the history of the meteorite. — D. B. V.

- 185-89. Hess, David C., Marshall, Royal R., and Urey, Harold C. Surface ionization of silver; silver in meteorites: *Science*, v. 126, no. 3286, p. 1291-1292, 1957.

The isotopic composition of silver in meteorites may reveal part of the early history of the solar system. Troilite from the Toluca (Xiquipilco) iron meteorite was found to contain no more than 1.6 ppm of silver, and a fragment of the Canyon Diablo iron meteorite (free of visually obvious troilite) no more than 1 ppm of silver. The $\text{Ag}^{107}/\text{Ag}^{109}$ ratios of meteoritic silver and terrestrial silver were found to agree within the limits of experimental error. — D. B. V.

- 185-90. Fowler, William A., and Hoyle, F. Nuclear cosmochronology: *Annals Physics*, v. 10, no. 2, p. 280-302, 1960.

The radioactive decays of uranium and thorium are applied in cosmochronology, in much the same manner as in geochronology, to two models representing different views as to the immediate source of the material that now constitutes the solar system.

In Model 1 (the autonomous galaxy) consideration of the decay of Th^{232} , U^{235} , and U^{238} leads to the conclusion that the age of the galaxy is $15^{+5}_{-3} \times 10^9$ yr. Similar considerations according to Model 2 (steady state cosmology and galactic-intergalactic exchange of matter) lead to the conclusion that the expansion time scale of the universe is $11 \pm 6 \times 10^9$ yr. The error can be reduced to $\pm 2 \times 10^9$ yr if the present Th/U ratio is chosen to give a $\text{Pb}^{208}/\text{Pb}^{206}$ age for the solar system that is concordant with that given by $\text{Pb}^{207}/\text{Pb}^{206}$, namely 4.5×10^9 yr. Application of radioactive decays to the chronology of the galaxy can no longer be made in a simple manner; however, the age found in the Model 1 calculations would seem to be a lower limit. — D. B. V.

- 185-91. Goles, Gordon, G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system: *Jour. Geophys. Research*, v. 66, no. 3, p. 889-898, 1961.

An attempt is made to account for the differences between the isotopic composition of terrestrial and meteoritic xenon reported by Reynolds (see *Geophys. Abs.* 183-66, -67). The two chief mechanisms (other than the decay of I^{129} to Xe^{129}) are the production of $\text{Xe}^{131-136}$ by spontaneous fission of now extinct nuclides in the earth, and the production of $\text{Xe}^{124-128}$ by nuclear spallation reactions in the early history of the solar nebula. About 9.6 percent of the Xe^{136} in the earth's atmosphere appears to have been derived from the spontaneous fission of Pu^{244} . The Pu^{244} - Xe^{136} decay interval of the earth is 290×10^6 yr, and its I^{129} - Xe^{129} decay interval may be estimated as $> 210 \times 10^6$ yr. Thus, the earth appears to be 100 - 200×10^6 yr younger than the meteorites. Possible errors in these determinations are discussed. A dating method based on the two decay systems I^{129} - Xe^{129} and Pu^{244} - Xe^{136} is proposed, and the appropriate equations are given. The initial solar-system ratios of $\text{I}^{129}/\text{I}^{127}$ and $\text{Pu}^{244}/\text{U}^{238}$, which can be determined by this method, would provide a crucial test of models of nucleosynthesis. — D. B. V.

- 185-92. Reynolds, John H. The age of the elements in the solar system: *Sci. American*, v. 203, no. 5, p. 171-174, 176, 178, 180, 1960.

Measurements of the U/He and K/Ar ratios in the noble gases trapped in the crystal lattices of meteoritic stone and iron show that the cold planetary bodies of the solar system all crystallized at about the same time - some 4.5 or 4.6 billion years ago. Moreover, measurement of the cosmic-ray produced He^3 , rather than just the He^4 which terminates the decay of uranium, makes it possible to determine the age and biography of the meteorite as a fragment of some larger parent body. The exposure or break-up ages of common stone meteorites are a few tens of millions of years, but those of iron meteorites are about 600 million years. A "contour map" of the distribution of He^3 , in a cross-section of a meteorite makes it possible to determine the original shape of the fragment.

An upper limit is placed on the age of the elements in the solar system by the existence now of U^{235} with its half life of 700 million years as compared to the half life of U^{238} of 4.5 billion years. If the original ratio of these isotopes was unity, then they were formed not more than approximately 6.6 billion years ago. The use of the I/Xe ratios to provide ultimately a reliable time scale for events at about the time the solar system was formed is discussed. Results to date with this method confirm the U^{235} evidence that the time interval between nucleogenesis and the formation of the minerals in the meteorites is relatively short. (See also *Geophys. Abs.* 183-66, -67, -68.) — V. S. N.

- 185-93. Wänke, H. Exposure ages for iron meteorites: *Nature*, v. 188, no. 4756, p. 1101-1102, 1960.
 Schaeffer, Oliver A. Exposure ages for iron meteorites: *ibid*, p. 1102, 1960.

Wänke points out that the exposure ages calculated by Schaeffer and Fisher (see *Geophys. Abs.* 182-73) cannot be correct, as they are based on two assumptions that cannot withstand examination: that the mean energy of particles producing spallations decreases with depth from the surface, and that the $\text{He}^3/\text{Ar}^{38}$ ratio is a measure of the mean energy of the particles.

Schaeffer replies that the exposure ages were not based on assumptions, but on experimental observations which indicate a relation between the $\text{He}^3/\text{Ar}^{38}$, He^3/He^4 , and $\text{He}^4/\text{Ar}^{38}$ ratios and the production rate of the radioactive nuclides Cl^{36} and Ar^{39} by cosmic rays. — D. B. V.

- 185-94. Stauffer, Heinz. Cosmogenic argon and neon in stone meteorites: *Jour. Geophys. Research*, v. 66, no. 5, p. 1513-1521, 1961.

The abundance and isotopic composition of argon and neon in six chondrites and an achondrite have been measured. The results of previous investigations are confirmed, namely Ar/K ages from 1.3 to 4.6 billion years and exposure ages from 4 to 24 million years. It is shown that the differences of the ratios $\text{Ar}^{36}/\text{Ar}^{38}$ are due mainly to small amounts of trapped primordial or atmospheric argon. Using the corrected Ar^{38} abundances, a value of 9.0 with a total spread of ± 20 percent is found for the corrected $\text{Ne}^{21}/\text{Ar}^{38}$ ratios. The possibility of diffusive losses of cosmogenic rare gases is discussed. — Author's abstract

- 185-95. Goles, Gordon G., and Anders, Edward. Iodine content of meteorites and their $\text{I}^{129}\text{-Xe}^{129}$ ages: *Jour. Geophys. Research*, v. 65, no. 12, p. 4181-4184, 1960.

Iodine and tellurium abundances in chondritic meteorites were determined by neutron activation analysis. For 6 bronzite and hypersthene chondrites, iodine abundances range from 37 to 104 ppb, and for 9 enstatite and carbonaceous chondrites the range is from 127 to 560 ppb; the tellurium abundances range from 0.42 to 0.73 ppm and 1.23 to 3.4 ppm respectively.

Using the continuous nucleosynthesis model, the $\text{I}^{129}\text{-Xe}^{129}$ decay intervals, measured from the cessation of nucleosynthesis, were calculated to be $119_{-8}^{+9} \times 10^6$ yr for Richardton, $97_{-10}^{+17} \times 10^6$ yr for Indarch, $106_{-8}^{+9} \times 10^6$ yr for Murray, and $>190 \times 10^6$ yr for Beardsley. The iodine content of Richardton is about a factor of 20 less than that assumed by Reynolds (see *Geophys. Abs.* 183-68), so that the decay interval is considerably shorter than his original estimate. The apparent difference in values for Richardton and Indarch is not statistically significant. — D. B. V.

- 185-96. Read, William F. The Saxeville meteorite: *Wisconsin Acad. Sci., Arts, and Letters Trans.*, v. 49, p. 191-198, 1960.

The Saxeville meteorite was found many years ago about 5 miles southwest of Saxeville, Waushara County, Wis. The original mass is said to have weighed 3.6 kg but only 687 g can be accounted for now in major collections. This study is based on 236 g in the collection at Lawrence College. The metallic portion of the meteorite is mainly granular-octahedral Ni-Fe with scattered blebs of schreibersite and troilite; the stoney portions are a crystalline mosaic of 46 percent pyroxene, 32 percent olivine, 0.5 percent plagioclase, and 21.5 percent Ni-Fe and troilite. The metal is in veins intruded along fractures in the stoney material and replacing it to a limited extent. — V. S. N.

- 185-97. Krinov, E. L. The Kaaliyarv meteorite craters on Saaremaa Island, Estonian S.S.R.: *Am. Jour. Sci.*, v. 259, no. 6, p. 430-440, 1961.

An investigation of one large and six small meteorite craters in Estonia is reported. It is concluded that the large crater is the result of an explosion caused when a large meteorite traveling at remaining cosmic velocity collided with the earth. The smaller craters, formed by the same meteorite shower, are impact craters formed by smaller fragments which had been slowed by the atmosphere until all cosmic velocity was lost and thus could not produce an explosion at the point of impact. No fragments of meteorites are associated with the small craters in contrast to the many associated with the large crater.

Comparison is made with similar crater groups in Sikhote-Alin, U.S.S.R.; Henbury, Australia; and Brenham, Kan. — V. S. N.

- 185-98. Thiel, Edward, and Schmidt, Richard A. Spherules from the Antarctic ice cap: *Jour. Geophys. Research*, v. 66, no. 1, p. 307-310, 1961.

A study of spherules contained in Antarctic ice cores leads to improved values for the size distribution and annual mass deposit of these distinctive extraterrestrial particles. Previous estimates of the annual deposit based on collections from air and from ocean sediments have varied from 8 metric tons to 2,000,000 metric tons per year. The figure derived from the present study is 184,000 metric tons per year. — Authors' abstract

- 185-99. Pettersson, Hans. Cosmic spherules and meteoritic dust: *Sci. American*, v. 202, no. 2, p. 123-126, 128, 130-132, 1960.

The amount of extraterrestrial material that is contributed to the earth by meteor-falls is estimated from a study of cosmic spherules in deep ocean sediments and of meteoritic dust in the atmosphere to be about five million tons per year. Deep sea cores from the Pacific, containing sediments 7.5 to 15 million years old in the lowest parts, show a cosmic spherule count that varies from point to point on the ocean floor and from one period to another down the length of the core; in general, however, the count is higher in the upper, more recent sediments and lower in the more ancient sediments. Cores from other oceans show this same tendency. To estimate the amount of meteoritic material falling on the earth today, a collection of meteoritic dust is being made. Collections are made from high mountains in areas relatively uncontaminated with terrestrial dust; cosmic dust is distinguished from terrestrial dust by the presence of nickel. If five million tons of meteoritic dust fall to the earth each year of which 2.5 percent is nickel, the amount of nickel added to ocean sediments would be .017 percent of the total red clay deposited in a year. This is well within the 0.44 percent nickel content of deep-sea sediments and makes the five-million-ton per year figure seem conservative; the figure of 14 million tons actually arrived at from dust collections may be more accurate. (See also *Geophys. Abs.* 172-145, 173-234, 184-83.) — V. S. N.

- 185-100. Gourinard, Yves. Sur la présence de sphérules cosmiques dans des roches sédimentaires [On the presence of cosmic spherules in sedimentary rocks]: *Acad. Sci. [Paris] Comptes Rendus*, v. 251, no. 22, p. 2558-2560, 1960.

Cosmic spherules have been recovered from Pliocene clays near Algiers that are about the same age as the oldest Pacific sediments examined by Pettersson (see *Geophys. Abs.* 185-99). Their average size is smaller than that of the Pacific spherules (most are 10-20 μ), but they are more abundant

(100-400 spherules per kg). An Upper Bajocian calcareous marl from Tagremaret (Oran) also furnished spherules, but in less abundance with respect to total mass of rock (some tens per kg at most).

If it can be shown on the basis of absolute age data that the abundance and size distribution of cosmic spherules has varied in the course of geologic time, they would constitute exceptionally good stratigraphic horizon markers, which are strictly contemporaneous and of worldwide distribution. — D. B. V.

- 185-101. Taylor, S. R., Sachs, Maureen, and Cherry, R. D. Studies of tektite composition-I. Inverse relationship between SiO_2 and the other major constituents: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 155-163, 1961.

The relation of SiO_2 to the other major constituents in tektites has been studied (see also *Geophys. Abs.* 183-78). It is concluded that a significant inverse relationship exists between SiO_2 and the other constituents, and that Al_2O_3 , FeO , MgO , CaO , Na_2O , and K_2O display positive correlations among themselves. — D. B. V.

- 185-102. Cherry, R. D., and Taylor, S. R. Studies of tektite composition-II. Derivation from a quartz-shale mixture: *Geochim. et Cosmochim. Acta*, v. 22, no. 2-4, p. 164-168, 1961.

The inverse relation between SiO_2 and the other major constituents of tektites (see *Geophys. Abs.* 185-101), together with the presence of lechatelierite, is explained on the basis of a physical mixing process. A close match to the average composition of tektites is produced by a mixture of 25 percent quartz and 75 percent nonvolatile (at $1,700^\circ\text{C}$) constituents of shale. (See also *Geophys. Abs.* 183-78). — D. B. V.

- 185-103. Salisbury, John W. An introduction to the moon: U.S. Air Force Research Division, Geophysics Research Directorate, TN 60-456, 30 p., 1960.

Present knowledge and theories concerning the origin of the moon and the lunar surface structures are summarized primarily for the use of laymen, schools, and teachers. The following chapters are included: introduction, origin of the moon, lunar interior, lunar surface, and lunar experiments. In conclusion, a brief list of references is given. — V. S. N.

- 185-104. LeRoy, L. W. Lunar features and lunar problems: *Geol. Soc. America Bull.*, v. 72, no. 4, p. 591-604, 1961.

The major features of the moon (mares, highlands, craters, fractures) are briefly reviewed to encourage geologists to participate in the solution of lunar problems—problems involving the interpretation of varied land forms, the rock types and their distribution, potential ore deposits, and lunar tectonics. Special attention is given to fracture systems, the origin of the lava filling many closed craters, and the origin of the central peak complexes. — Author's abstract

- 185-105. Bolt, Bruce A. Spheroidal oscillations of the moon: *Nature*, v. 188, no. 4757, p. 1176-1177, 1960.

Periods of natural vibration of three spherical gravitating models of the moon have been calculated on an IBM 7090 electronic computer. The values provide basic information for lunar space research concerned with the design

of experiments to investigate the structure of the moon. Each model is completely solid and has a radius of 1,738 km and mean density of 3.33 g per cm^3 . Model I is a homogeneous sphere with P- and S-wave velocities of 8.2 and 4.7 km/sec, respectively; Model II has a density distribution close to that calculated by Jeffreys (1937) for the self-compression of a moon composed of ultrabasic rock with a surface density of nearly 3.28 g per cm^3 ; and Model III has a rather extreme density distribution, with a surface value of 2.60 g per cm^3 , near that of granite.

The results, which are tabulated, indicate that the deviation of the moon from homogeneity can be measured using observations of the long-period spectrum of free vibrations. An ultra-long period seismometer or tidal gravimeter placed on the moon, designed to record periods up to 16 min, should provide more detailed information on the deep interior than the short-period seismometer suggested by Press and others (see Geophys. Abs. 183-88). — D.B.V.

- 185-106. Watson, Kenneth, Murray, Bruce, and Brown, Harrison. On the possible presence of ice on the moon: *Jour. Geophys. Research*, v. 66, no. 5, p. 1598-1600, 1961.

It is argued that water is far more stable on the lunar surface than SO_2 or noble gases because of its extremely low vapor pressure at low temperatures, and that it may well be present in appreciable quantities in shaded areas in the form of ice. The fraction of lunar surface that is in permanent shade is estimated to be 1.2×10^{-4} ; if so, the area of exposed ice would be $4.5 \times 10^{13} \text{ cm}^2$ and the escape rate would be $1.9 \times 10^{-18} \text{ g per cm}^2 \text{ per sec}$. Over the life span of the moon this would correspond to a loss of 0.28 g per cm^2 . If the moon evolved as the earth did, $3.0 \times 10^4 \text{ g per cm}^2$ of water would have been liberated on the surface; in addition, $8.3 \times 10^{-21} \text{ g per cm}^2 \text{ per sec}$ is added by sporadic meteorite impact, and some is liberated from lunar crustal material as the result of impact. When suitable instruments can be placed in the dark areas to determine the presence or absence of ice, the result may reveal much concerning early lunar history. — D. B. V.

- 185-107. MacDonald, G[ordon] J. F. Interior of the moon: *Science*, v. 133, no. 3458, p. 1045-1050, 1961.

Present knowledge and theories concerning the physical and thermal state of the moon and of its stress history and dynamic history are reviewed. Despite the abundance of observations, the origin of many of the surface features remains in doubt. Very few data relate to the nature of the moon's interior. Direct observations, either from orbiting lunar satellites or from instruments on its surface (seismic stations, tidal gravimeters, heat flow measuring apparatus), would do much to reduce the present uncertainty. — D. B. V.

- 185-108. Bülow, Kurd von. Fundamentaltektonische Parallelen zwischen Mond und Erde [Fundamental tectonic parallels between moon and earth]: *Forschungen u. Fortschritte*, v. 33, no. 1, p. 1-4, 1959.

Comparison of the known features of earth and moon shows that the two bodies are alike in their fundamental structural style, suggesting parallels in their structural history. — D. B. V.

- 185-109. Bülow, Kurd von. Zur Deutung der Lunik-Aufnahmen von der Rückseite des Mondes [On the interpretation of the Lunik photographs of the back of the moon]: *Forschungen u. Fortschritte*, v. 34, no. 3, p. 65-66, 1960.

This is a brief description, with sketch, of the features visible in the Russian photographs of the back of the moon. — D. B. V.

Schrader, C. D., and Stinner, R. J. Remote analysis of surfaces by neutron-gamma-ray inelastic scattering technique. See *Geophys. Abs.* 185-511.

EARTH CURRENTS

- 185-110. Roberts, P. H., and Lowes, F. J. Earth currents of deep internal origin: *Jour. Geophys. Research*, v. 66, no. 4, p. 1243-1254, 1961.

The current system flowing in the earth's core that is responsible for the dipole geomagnetic field is toroidal and does not appreciably extend into the mantle. However, the mechanism supporting these currents almost certainly generates in addition a poloidal current system that does extend into the mantle and that could, in principle, be measured at the earth's surface. In this paper the current distribution in the mantle is examined for several assumed distributions of conductivity in the mantle. The effect of the oceans is also briefly considered. It is found that the potential gradient at the surface of the earth associated with these deep earth currents may be of the order of a mv per km if thermoelectric emf's at the core boundary contribute appreciably to the magnetic field, but will be smaller if the primary emf's are inside the core. — Authors' abstract

- 185-111. Garland, G. D. Earth currents, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 277-307, 1960.

Electric currents that are on a sufficient scale to be useful in study of the earth as a whole are considered in this paper. The emphasis is on the general instrumental requirements for specific applications rather than on technical details, because much of the instrumentation required for measurement of earth currents is well understood. The following are discussed: measurement of earth currents, general nature of earth-current records, electromagnetic induction in the earth, and particular applications of earth-current measurements. It is suggested that apart from the study of crustal structures, earth current observations should lead to a better understanding of difference in properties from place to place in the upper mantle. In conjunction with magnetic observations they should assist in determining the nature of the sources of disturbance for effects of various periods. Finally, there is the possibility of locating components of the measured currents that are not the result of induction by an external varying magnetic field; this could be highly important if the currents could be shown to be related to a toroidal magnetic field in the core or to mantle-core currents. — V. S. N.

- 185-112. Fournier, Hugo. Sur une polarisation sélective remarquable des courants telluriques enregistrés à Garchy [On a remarkable selective polarization of telluric currents recorded at Garchy]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 4, p. 562-564, 1961.

Earth currents of "intermediate" period recorded at the Nivernais Geophysical Station at Garchy, France, are distinctly channeled in an approximately north-south direction. The polarization becomes perceptible for periods of 5 sec, is most distinct in those of about 5 min, and ceases to be perceptible for periods of the order of 3 hr. Channeling of earth currents is

known elsewhere; what is remarkable here is its selective character. It evidently occurs in the intermediate layers of the crust, in which the intermediate-frequency currents flow. — D. B. V.

- 185-113. Tarczy-Hornoch, A[ntal]. Bericht des observatoriums bei Nagycenk (Ungarn) über die Ergebnisse der Erdstromregistrierungen in den beiden Halbjahren 1958 [Report of the observatory near Nagycenk (Hungary) on the results of earth current recordings in both halves of 1958]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 337-422, 1960.

Earth current data obtained at the Nagycenk observatory in Hungary in 1958 are presented in extensive tables and graphs. — D. B. V.

Forstendorfer, G[ottfried]. Experiments with the use of stray currents in geophysical prospecting. See Geophys. Abs. 185-182.

EARTHQUAKES AND EARTHQUAKE WAVES

- 185-114. Lotze, Franz. Aktuo-geologische Charakteristik des Jahres 1958 [Actuo-geologic characteristics of the year 1958]: Neues Jahrb. Geologie und Paläontologie Monatsh., no. 12, p. 529-545, 1959.

In 1958 in central Europe 816 definite earthquakes were registered. Their monthly distribution is tabulated. Epicenters were determined for 59 percent of them; of these, 65 were in Europe and the Mediterranean area, 3 in Africa, 23 in the Atlantic and Arctic Oceans, 28 in India and Indonesia, 259 in the western and northwestern half of the Pacific Ocean, and 56 in its southeastern half. There were 82 shocks of magnitude 6 or more, 7 with $M \geq 7$, and 1 with $M=8$; their regional distribution is given. There were more than twice as many shocks with focal depths greater than 50 km than in 1957; they were distributed as follows: 14 at 50-90 km, 24 at 100-190 km, 10 at 200-350 km, and 16 at 400-650 km. Their geographic distribution is given.

Volcanic activity in 1958 included the further development of Ilha Nova (Cape-linhos) in the Azores, and eruptions of Goma and another volcano in the Belgian Congo, Etna and Stromboli in Europe, Aso and Asama in Japan, and Manam in New Guinea. — D. B. V.

- 185-115. Due Rojo, Antonio. Notas sísmicas de 1958 [Seismic notes, 1958]: Rev. Geofísica, v. 18, no. 70, p. 207-215, 1959.

Progress in seismology in 1958 is reviewed briefly; and mention is made of the numerous International Geophysical Year activities all over the world, development of very long-period seismographs, calculations of the shape of the earth's core, studies of the relation between microseisms and seismicity of the areas where they were registered, and studies of waves generated by nuclear explosions. The world distribution of epicenters of 1958 earthquakes is shown on a map, and macroseismic data concerning the most noteworthy shocks are reviewed by region (Europe, Asia, North and South America, and Oceania). — D. B. V.

- 185-116. Due Rojo, Antonio. Notas sísmicas de 1959 [Seismic notes for 1959]: Rev. Geofísica, v. 19, no. 74, p. 183-188, 1960.

Earthquake activity in various parts of the world during 1959 (Europe, Asia, Africa, America, and Oceania) is reviewed briefly. A table shows the distribution of magnitudes and focal depths, and a map gives the geographic position of the 1,192 epicenters determined for 1959. — D. B. V.

- 185-117. Berg, Joseph W., Jr. Earthquakes near Nephi, Utah, on November 28, 1958, and December 1, 1958: Utah Acad. Sci. Proc., v. 37, p. 77-79, 1960.

One earthquake occurred November 28, 1958 and three on December 1, 1958, near Nephi, Utah. The shocks ranged between 4 and 5 in maximum intensity on the Modified Mercalli Scale. Instrumental determinations for the epicenters were not possible, and all epicenters were assumed to be at one location, lat $39^{\circ}42.7' N.$, long $111^{\circ}50.0' W.$ Body shear waves traveled the 115.6 km to Salt Lake City at an average velocity of 3.5 ± 0.1 kmps. — V. S. N.

- 185-118. Schulz, R[udolf]. Breve descripción de los terremotos de Chile de Mayo de 1960 [Brief description of the earthquakes in Chile in May 1960]: El Salvador Servicio Geol. Nac. Bol. Sismol., v. 6, p. 23, 1960.

The time of occurrence and magnitude of the Chilean earthquakes of May 21-22, 1960 and the damage and topographic changes wrought are described very briefly. The occurrence of three strong shocks ($M=7 \frac{3}{4}$, $7 \frac{3}{4}$, and $8 \frac{1}{2}$) within a few minutes of each other—particularly the last two, which were only a half minute apart—provoked very slow oscillations of the whole surface of the globe of more than 1 cm amplitude, which were recorded by long-period seismographs. — D. B. V.

- 185-119. Pfluke, John H. Agadir earthquake of February 29, 1960—seismicity and geology of the area: Earthquake Notes, v. 31, no. 4, p. 46-50, 1960.

The Agadir earthquake of February 29, 1960 occurred in a well-defined belt of earthquakes that extends the length of Morocco and branches off the large Alpine belt which forms a loop about the Western Mediterranean. Seismic activity in Morocco seems to follow mountain ranges; beginning where the Alpine belt divides the Moroccan branch, continues down the Middle and High Atlas ranges with a sub-branch following the Rif mountain range. A striking alignment of epicenters occurs along the Atlas ranges. Epicenters are located along two lines—one directed N. 25° E. and paralleling the trend of Hercynian folding, and the other directed N. 55° E. and paralleling the trend of the Alpine tectonic axis. The epicenter of the Agadir earthquake was located on the latter alignment. A fault plane solution by the P-wave first motion method is attempted for the Agadir earthquake. The fault strike of the first solution closely parallels the strike of surface faults in the area. To eliminate the ambiguity, the two P-wave solutions are compared with the polarization of S-waves observed at a number of seismic stations. From this it seems probable that the fault break may have occurred on a downward extension of either the Casbah or Tildi fault. — V. S. N.

- 185-120. Sahlström, K. E., and Båth, M[arkus]. Jordskalv i Sverige 1951-1957 [Earthquakes in Sweden, 1951-57 (with German summary)]: Sveriges Geol. Undersökning, Årsb. 52, no. 5, (Ser. C, no. 562) 19 p., 1958.

Twenty-two earthquakes were observed macroseismically in Sweden in the period 1951-57. The strongest, with an intensity of 4-5 (Rossi-Forels scale), occurred on August 26, 1956 in northern Hälsingland and was felt over an area of $4,500 \text{ km}^2$. Two others, of intensity 4, were felt over wider areas: March 5, 1953 over $14,000 \text{ km}^2$ in western Värmland, Dalsland, and northern

Bohuslän; and January 21, 1956 over 6,000 km² around Arjeplog in Lappland. Seven shocks were felt in 1956, 5 in 1955, 3 each in 1953 and 1957, 2 in 1951, and 1 each in 1952 and 1954. Epicenters are shown on a map. Each shock is described briefly. — D. B. V.

Yevseyev, S. V. The earthquake of February 20, 1951 and the structure of the earth's crust in the Transcarpathian region. See *Geophys. Abs.* 185-356.

185-121. Kukhtikova, T. I., and Yeferina, G. P. O polozhenii epitsentra Stalinabadskogo zemletryaseniya 1952 g. [On the location of the epicenter of the Stalinabad earthquake of 1952]: *Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy*, v. 6, p. 151-170, 1960.

On the basis of study of instrumental data on the Stalinabad earthquake of 1952, the epicenter was found to be located within the Bassar valley close to the zone of maximum seismicity. — A. J. S.

185-122. Petrushevskiy, B. A. K geologicheskoy obstanovke Gan'suyskogo zemletryaseniya 1920 g [On the geologic conditions of the Kansu earthquake of 1920]: *Akad. Nauk SSSR Doklady*, v. 129, no. 2, p. 412-415, 1959.

The earthquake of December 19, 1920 in Kansu province in northwestern China was one of the strongest registered anywhere during the period 1904-56. Its magnitude (m) was 7 3/4 and its intensity 11-12 points. Although the epicenter was far from any large cities, there were 100,000-250,000 casualties.

The epicentral zone of this earthquake was visited by Petrushevskiy in December 1958. At first glance it is impossible to detect any of the geologic features usually associated with high seismicity. There seem to be no major faults at or near the surface. There has been no recent structural reorganization nor is there any abrupt change in structural plan. Recent tectonic movements have no distinct surface expression; were it not for the numerous earthquakes, some of them strong, such movements would be considered to be negligible. The area is an epi-Hercynian platform, the general geologic conditions of which are reminiscent of the Kazakh folded region where basement rocks of an epi-Hercynian platform crop out; the latter is practically aseismic, however. An investigation of the seismicity of Kansu province, planned for the near future by Chinese seismologists, should be of great seismo-geologic interest. — D. B. V.

185-123. Hsieh, Yü-show. The Kuo-Hsien earthquake of October 8, 1952 (in Chinese with English abstract): *Acta Geophys. Sinica*, v. 7, no. 2, p. 83-90, 1958.

A destructive earthquake occurred on October 8, 1952 in the Hu-tuo River valley near Kuo-Hsien, Shansi Province, China. The hypocenter was at lat 38°53' N., long 112°51' E. The magnitude was only 5.3 but the epicentral intensity attained a value of 8; the $\bar{S}-\bar{P}$ interval of several aftershocks was only 2 sec; and the Nanking and Zi-Ka-Wei seismograms showed relatively small amplitudes of body waves. From these facts it was concluded that the focal depth was shallower than usual. The rising earthquake intensity at places along the river is illustrated; it shows clearly the effect of ground condition and water table on earthquake destructiveness. The destructiveness of the earthquake was large because of the unconsolidated nature of the river valley sediments. — V. S. N.

- 185-124. Aver'yanova, V. N., Fedotov, S. A., and Ferchev, M. D. Predvaritel'nyye dannyye o zemletryasenii i tsunami 6 noyabrya 1958 g. [Preliminary data on the earthquake and tsunami of November 6, 1958]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 9, p. 88-99, 1961.

The earthquake of November 6, 1958 at 22^h58^m (G.m.t.) occurred on the west slope of the Kurile deep sea basin off Iturup (Etorofu) island and caused a tsunami. The magnitude, according to Moscow, Pulkovo, Irkutsk, and other stations, was $M=8.0$; focal depth was 80 km according to SP-P differences. The SP phase was clearly recorded at Klyuchi, Vladivostok, Moscow, Pulkovo, and other U.S.S.R. stations and correlated well from station to station. Origin time was calculated as 22^h58^m14^s, using the method of least squares according to the Wadati formula. Provisional epicentral coordinates are $\phi=44.25^\circ$ N., $\lambda=149.0^\circ$ E. Numerous aftershocks occurred through December. The strongest of these ($M=7$) was on November 12 at 20^h; its epicenter was close to that of the main shock.

The earthquake was felt for 500 km along the Kurile Islands from Kunashiri to Uruppu, with almost equal intensity (about 8 points), indicating its great depth and energy. Macroseismic effects are described briefly. The tsunami produced by the earthquake is discussed in more detail. Its relatively small size can be explained by the great depth of focus and by the fact that the southern Kurile Islands are bordered by a broad shallow-water zone on the ocean side. — D. B. V.

- 185-125. Lee, S. P. A practical magnitude scale [in Chinese with English abstract]: Acta Geophys. Sinica, v. 7, no. 2, p. 98-102, 1958.

A practical magnitude scale is suggested to estimate the magnitude of ancient earthquakes for which only simple historical records are available. An empirical formula, $M=0.58 I_0+1.5$ (where M is magnitude and I_0 is intensity at epicenter), is derived from instrumental and field observations of 35 recent earthquakes in China. Using this formula, a practical magnitude scale in tabular form is constructed. It is concluded that the resulting estimates of magnitude for the ancient earthquakes are accurate to within half-a-scale of magnitude. — V. S. N.

- 185-126. Kvale, Anders. Earthquakes, in Geology of Norway: Norges Geol. Undersøkelse Skr., no. 208, p. 490-506, 1960.

Seismic activity in Norway is greater than in the other Scandinavian countries and epicenters that have been located with sufficient accuracy are located on known or inferred fault zones. Seismological research since 1887 when written records were first instituted, the number and distribution of earthquakes, the regions of seismic activity, location of epicenters and their relation to tectonics, depth of hypocenters, thickness of crustal layers, the earthquake of October 23, 1904, and the causes of earthquakes in Norway are discussed.

It is concluded that post-glacial uplift is not the cause of all Norwegian earthquakes. Faulting has occurred in Norway since Precambrian times, and some of these faults are still active as loci of earthquakes. Faults of Silurian, Devonian, and Permian origin are also known and the greatest historic earthquake (1904) occurred on one of the latter. It is unlikely that present movements inside and outside the coastal areas of Norway should have a cause different from movements on the same faults in Tertiary times, especially as Tertiary movements are still continuing in other parts of the North Atlantic. — V. S. N.

- 185-127. Panasenko, G. D. Zemletryaseniya Kol'skogo poluoostrova i Severnoy Karelii i ikh svyaz' s sovremennymi dvizheniyami Baltiy-skogo shchita [Earthquakes of the Kola Peninsula and northern Karelia and their relation to recent movements of the Baltic shield]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 8, p. 200-205, 1960.

The Baltic shield is an area of intensive recent crustal movement. In the Kola Peninsula and northern Karelia there is not only geologic and geomorphic evidence of the movement, but perceptible earthquakes also occur. Most of these do not exceed 4 points in intensity, but a few reach 6 or more. Instrumental observations, begun in 1956, show that very weak earthquakes are very numerous. The distribution of epicenters and the seismic zoning are shown on a sketch map. The earthquake zones are apparently related to large-scale fractures produced or rejuvenated by upwarping of the Baltic shield. — D. B. V.

- 185-128. Kirillova, I. V., and Sorskiy, A. A. Tektonika i seysmichnost' Kavkaza [Tectonics and seismicity of the Caucasus (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 158-170, 1960.

The distribution of seismic activity in the Caucasus is irregular in space and time. In a general way, it is greater in the eastern part, where recent differential vertical movements are more pronounced, than in the western part. Longitudinal and transverse zones of higher activity can be distinguished against a general background of rather high seismicity. Two main seismogenic zones are delineated, a deep horizon where mass displacements produce transverse geotectonic zoning and deep-focus earthquakes with generally north-south displacements, and an upper horizon in which mass displacements produce longitudinal zoning and shallow earthquakes.

The most active areas lie where deep faults of Caucasian (northwestern) trend are intersected by transverse deep faults. Such "seismic nodes" are typical of the southeastern Caucasus (Shemakha area) and parts of Armenian S.S.R. and Georgian S.S.R. Areas with reactivated unidirectional deep faults are characterized by relatively moderate seismicity. Areas of low seismicity are those lacking deep faults, in which tectonic movements are slight. — D. B. V.

- 185-129. Hamamatsu, O. Seismicity of shallow earthquakes in and near Japan during 1926-1956 [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 97-107, 1960.

Formulas are given to show the relationship between the annual number and the magnitude of shallow earthquakes occurring in Japan as a whole, in northeast Japan, and in southwest Japan from 1926 through 1956. — V. S. N.

- 185-130. Ichikawa, M. On the relation between earthquake magnitude and maximum value of epicentral distance at limit of perceptibility [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 83-87, 1960.

The following formulas are presented for estimating the magnitude of a shallow earthquake in or near Japan from the distance between epicenter and limit point of perceptibility: $M=2.7 \log \Delta - 1.0$ or $M=2.7 \log \Delta + 0.000063 \Delta - 0.96$. Modifications are given for adapting the formulas to earthquakes in northeast Japan and in central and southwestern Japan. — V. S. N.

- 185-131. Tazieff, Haroun. À propos de la signification tectonique des importants glissements de terrains provoqués par le grand séisme du Chili de mai 1960 [Concerning the tectonic significance of large landslips provoked by the great Chilean earthquake of May 1960]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 20, p. 2204-2206, 1960.

At 200 km from the submarine epicenter of the Chilean earthquake of May 22, 1960, numerous landslide phenomena were produced in a vast area extending over almost two degrees of latitude in the spurs of the Andes Cordillera. Some avalanches of loose material descended hundreds of meters in altitude and acquired a force capable of propelling the mass far over the subhorizontal valley bottom, as is the case in avalanches of powdery snow. In some places, however, masses ranging from some tens of thousands to several million cubic meters of material were stripped from locations only 40-100 m above the valley floor and displaced long distances over the flat bottom; gravity acceleration alone could not have produced horizontal movement of this order. Evidently a mechanism analogous to that of a shaking table can operate during a single shock and cause material to be carried several kilometers. This concept might throw light on certain aspects of tectonics, particularly Alpine tectonics, that have not yet been satisfactorily explained. — D. B. V.

- 185-132. Ritsema, A. R., and Veldkamp, J. Fault plane mechanisms of southeast Asian earthquakes: Koninkl. Nederlands Meteorol. Inst. Mededel. en Verh., no. 76, 63 p., 1960.

Fault plane solutions are presented for 48 earthquakes in southeast Asia. Methods used are discussed and solutions are given in tables which are followed by an analysis of each earthquake. It is concluded that (1) the mechanism at the focus of the earthquakes treated here differs little from the assumed "single-couple" theory; (2) the fault motion and principal earthquake generating stresses are in a more or less vertical plane for deep shocks and in a more or less horizontal plane for shallow shocks; (3) fault motion is generally directed either about perpendicular to or about parallel with the direction of the geological structures at the surface; (4) B-axes are generally situated in a vertical plane through the tectonic structural lines; (5) fault motions of large earthquakes, $M > 7\frac{1}{2}$, show a tendency to be directed in NNW-SSE azimuths independent of the seismic zone to which the shocks belong; (6) combined normal and reverse fault earthquakes are 25 percent higher in the "Mediterranean" zones of Sumatra, Sunda arc, Celebes, and the Philippines than in the "Pacific" zones of the Solomon Islands and New Guinea; (7) positions of principal stress components of shocks do not suggest clearly a common stress field for all earthquakes in any one zone; and (8) a geographical distribution of earthquake types is shown if the area is divided into smaller parts of seismic zones about 2,000 km long, such as the Sumatra-Sunda Strait, Java - Timor, N. Celebes, Philippines, Solomon Islands, E. New Guinea, W. New Guinea, and Moluccas regions. — V. S. N.

- 185-133. Kukhtikova, T. I. Dinamicheskaya kharakteristika nurekskikh zemletryaseniy [The dynamic characteristics of the Nurek earthquakes]: Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 141-150, 1960.

The results of determinations of dislocations in the source region of the Nurek earthquakes are reported, and conclusions are drawn on the stability of the dislocation mechanism in the first shock and in the strong aftershocks. A similarity is noted between the strike of the ruptures on the surface and the orientation of faults at the earthquake sources. — J. W. C.

- 185-134. Mikumo, Takeshi. Generation mechanism of local earthquakes in Waykayama region [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 2, p. 65-77, 1960.

This is a shorter version of the paper previously published in Kyoto Univ. Coll. Sci. Mem., ser. A, v. 29, no. 2, p. 221-240, 1959 (see *Geophys. Abs.* 180-54). — V. S. N.

- Scheidegger, A[drian] E[ugen]. Faults and earthquakes. See *Geophys. Abs.* 185-287.

- 185-135. Oulianoff, Nicolas. Problème du Flysch et géophysique [The flysch problem and geophysics]: *Eclogae Geol. Helvetiae*, v. 53, no. 1, p. 155-160, 1960.

The conditions under which flysch deposits form are examined. It is concluded that waves, most marine currents, and gravity slumping are inadequate to explain the transport of sediments, particularly on the gentle slopes of the continental platform, and that turbidity currents are too sporadic and localized to be the chief mechanism. Universal and perpetual vibration of the entire crust, the effect of countless shocks of different origins, is responsible for carrying sediments toward basins of accumulation. These shocks are due not only to earthquakes (which occur on the average of nearly 3,000 per day) but to microseismic agitation of local and regional origin such as tides, hurricanes, violent rains, atmospheric pressure variations, and abrupt temperature changes. The distribution of vibrations over the earth varies with space and time. — D. B. V.

- 185-136. Gutenberg, B[eno]. PKIKP and pseudo-PKIKP phases at distances of less than 140° : *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 250-257, 1960.

In several attempts to establish from observations the traveltime curve for PKIKP (called P' or P'' by some authors) the beginning of this curve has been drawn with a relatively strong curvature corresponding to a decrease of $dt/d\theta$ from roughly 4 sec per degree at $\theta=110^\circ$ to about 2 sec per degree at 130° . Apparently, traveltimes of different wave types had been combined. Actually, the observed traveltime curve of PKIKP is nearly a straight line in agreement with calculations. Near an epicentral distance of 115° the amplitudes of PKIKP increase by a factor of roughly 5. This probably indicates the transition from the diffracted to the direct PKIKP. The portions of the traveltime curves with a slope corresponding to $dt/d\theta$ near 4 sec per degree which erroneously had been attributed to PKIKP belong to several wave types which seem to follow P , pP , and sP or precede PP , each at roughly constant time intervals. Among causes for such multiplicity of phases are effects of irregularities in the earth, of discontinuities, and of diffraction. — Author's summary

- 185-137. Bullen, K. E. A new method of deriving seismic velocity distributions from travel-time data: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 258-269, 1960.

A law of the form $v = ar^{5/0}$ gives a useful first approximation to the seismic velocity distribution in various parts of the earth. A method is devised here for finding the corrections to numerical values given by the law which are needed to fit a given set of seismic traveltime data. The method provides an alternative to the classical Herglotz method of determining velocity distribu-

tions and can be especially powerful in regions where the proportionate deviations from the above velocity law are small or moderate. The method is exact in spite of the nonlinear form of the first approximation.

Auxiliary notes are given that facilitate computation in particular cases. As an illustration, the method is applied to determining the P velocity distribution for the whole region E of the earth. The method illustrates anew the importance of the parameters ζ and α in ray theory. These parameters are defined as follows:

$$\eta = \frac{r}{v}; \quad \zeta = \frac{d \log v}{d \log r}; \quad \alpha = \frac{2}{1-\zeta} = \frac{2d \log r}{d \log \eta}$$

where v is the velocity at distance r from the center of the earth. — D. B. V.

- 185-138. Cagniard, Louis. Rigidité du Noyau et dualité des ondes sismiques qui s'y propagent [Rigidity of the core and quality of the seismic waves that propagate there]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 7, p. 1045-1047, 1961.

Because an electrical "double layer" lies between the core and mantle (see Geophys. Abs. 185-418) the equations of propagation are not at all the same as if the two mediums were found in direct contact. This results in the paradoxical behavior of seismic waves propagating across the core. The core is rigid and the K-waves are distortional. Condensation waves propagating in the core give rise to emergent waves that should not be imputed to diffraction of P-waves. — Author's abstract, D. B. V.

- 185-139. Yoshiyama, Ryoichi. Maximum amplitude and epicentral distance. — Proposed a theoretical elucidation of empirical formulas and some development: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 389-404, 1959.

Empirical formulas for maximum amplitude of an earthquake as a function of epicentral distance are of three types: $\log A = a - m \log \Delta$, $\log A = a - m \log \Delta - k \Delta$, and $\log A = a - m \log \Delta - f(T) \Delta$, where A = observation of maximum amplitude, Δ = epicentral distance, T = period, and a , m , and k are constants. Differences among these formulas are shown by purely mathematical analysis and by their application to observations of 7 destructive Japanese earthquakes.

One of the most important problems is to determine which of the formulas is most appropriate for a given earthquake. Toward this end, the formulas are deduced from a presumed fundamental law of wave attenuation. Three assumptions involved in this treatment are discussed. Then the spectrum of the earthquake wave at its origin $[B(t)]$ and the period (T) of the maximum amplitude in two earthquakes are calculated from the observed $A \sim \Delta$ relation, assuming the same fundamental law of attenuation; differences in the resulting expressions for $B(t)$ correspond to differences in magnitude. — D. B. V.

- 185-140. Katsumata, M. The effect of seismic zones upon the transmission of seismic waves [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 89-95, 1960.

A correlation is shown to exist between the seismicity of an area and the velocity and attenuation of the seismic waves. In an analysis of data from deep earthquakes which have occurred in central Honshu it is found that seismic waves traveling through the area of active seismicity to the northeast have greater velocities and attenuate more slowly than waves traveling through the area of low seismicity to the southwest. — V. S. N.

- 185-141. Caloi, Pietro. Sui tempi di tragitto delle onde sismiche nell'inter-no della Terra, con particolare riguardo al mantello terrestre [On the traveltimes of seismic waves in the interior of the earth, with particular reference to the earth's mantle]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 2, p. 130-136, 1959.

Formulas, based on Gutenberg's velocity values, are derived for the determination of traveltimes of seismic waves that traverse the mantle over epicentral distances corresponding to given angles of incidence. The dependence of ρ on ϕ^2 found in a previous paper (see *Geophys. Abs.* 144-12557) is expressed in a more rigorous form, permitting greater precision in the calculations.

Application of these formulas to the Aegean earthquakes of April 24 and 25, 1957, gives a traveltime of 944 sec to the Tolmezzo seismic station; this is 9 sec more than the observed traveltime and suggests that the focal depth was deeper than normal, or about 70 km. — D. B. V.

- MacDonald, Gordon J. F., and Ness, Norman F. A study of the free oscillations of the earth. See *Geophys. Abs.* 185-343.

- 185-142. Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion: *Jour. Geophys. Research*, v. 66, no. 3, p. 899-902, 1961.

Dispersion of short-period Rayleigh waves is studied in an effort to measure sedimentary rock thickness in the Mexican geosyncline. The measurement is approximate, but the study indicates uniformity of crustal structure over a very large area, including the Mexican geosyncline. Therefore the study suggests an economical method of measuring crustal thicknesses over the entire area. The study indicates that the average sedimentary thickness across the Mexican geosyncline is about 8 km. — Author's abstract

- Choudhury, Mansur Ahmed. On the general structure of the earth's crust in western Europe. See *Geophys. Abs.* 185-352.

- 185-143. Bisztricsány, Ede, and Kiss, Zoltán. Kéreg átlagvastagságának számítása eurásiai útra a Love-hullám diszperziós görbéje alapján [Computation of the mean crustal thickness on a Eurasian path based on Love wave dispersion curves (with English summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 147-150, 1960.

Analysis of Love wave dispersion for two earthquakes in southern China (January 21, 1931 and December 15, 1934) as recorded at Budapest gives an average crustal thickness of only 33 km, in spite of the fact that one third of the path is through high mountain areas. — D. B. V.

- 185-144. Payo Subiza, Gonzalo. Estudio sobre las ondas superficiales Lg, Rg y Li en los registros del Observatorio de Toledo [Study of the surface waves Lg, Rg, and Li in the records of the Observatory of Toledo]: *Rev. Geofísica*, v. 19, no. 75, p. 227-256, 1960.

The location of the Toledo (Spain) observatory in southwestern Eurasia is particularly favorable for the study of short-period waves (Lg, Rg, and Li) that have traveled purely continental paths. Such waves have been analyzed in the records of 80 selected earthquakes that occurred during 1941-59. Lg is clearly divided into two types: Lg1 ($v=3.61\pm0.09$ km/s) and Lg2 ($v=3.36\pm0.09$ km/s); Lg1 may in turn consist of two other waves. Velocities and periods

are calculated and compared with those determined by others. There is little variation in velocity when L_1 crosses mountain chains, and as in the case of L_g and R_g , the phase disappears when the path crosses oceanic structure. Recent theories of the mechanism of transmission of surface waves are discussed. — D. B. V.

- 185-145. Teupser, Christian. Zur Abstimmung und Eichung von elektrodynamischen Verrückungsmessern [On the tuning and calibration of electrodynamic displacement-measuring instruments (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 5, p. 269-289, 1960.

A moving-coilelectrodynamic seismograph gives a true response to ground displacement over a wide period range if a long-period pendulum with the usual damping is connected to a short-period, supercritically damped galvanometer. The best adjustment is obtained when the pendulum damping is 0.5 and the galvanometer damping is half as great as the ratio of the natural periods of the pendulum and galvanometer. The response characteristics of ground displacement, ground tilts, phase displacement, and the (ϕ_g, ϕ_g) curves are given for different tunings of the apparatus. The tapping test is suitable for determining the damping of the pendulum and the reaction factor. The necessary calibration functions are given in tables and approximate formulas. — D. B. V.

- 185-146. Gudzin, M[artin] G., and Hamilton, J[ack] H. Wichita Mountains Seismological Observatory: *Geophysics*, v. 26, no. 3, p. 359-373, 1961.

The physical plant and equipment of the new seismological observatory in the foothills of the Wichita Mountains, about 15 miles northwest of Lawton, Okla., are described, with photographs and schematic diagrams. The equipment includes short-period vertical, short-period horizontal, long-period (three-component), board-band (three-component), and narrow-band (three-component) seismometers located in 10 earth-covered vaults. Phototube amplifiers are housed in an intermediate building, and control and recording equipment are in a central recording building.

Background noise is low at this site. The location is at a convenient distance from California and Mexico earthquakes and should provide a significant contribution to the science of detecting and identifying underground nuclear explosions and earthquakes. — D. B. V.

- 185-147. Tokarev, P. I. Kozyrevskaya seismicheskaya stantsiya [The Kozyrevsk seismic station]: *Acad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta.*, no. 29, p. 54-55, 1960.

A second station for the study of volcanic earthquakes and tremors in Kamchatka was completed at the settlement of Kozyrevsk in September 1958. The location and equipment (3 Kharin regional seismographs with GK-6 galvanometers and RS-P recorder) are described briefly, and the constants of the instruments are tabulated. — D. B. V.

ELASTICITY

- 185-148. Phinney, Robert A. Leaking modes in the crustal waveguide. Part 1. The oceanic PL wave: *Jour. Geophys. Research*, v. 66, no. 5, p. 1445-1469, 1961.

The problem of the seismic signal associated with the earliest P-wave is treated by application of normal mode theory, in which the signal is regarded as a quasi-surface wave coupled both to the motion of the earth's layered surface and to body waves propagating in the underlying mediums. Predictions made for this model are relevant to explosion and earthquake sources. The oscillatory "tail" following the initial P motion is explained.

Rosenbaum's transient solution for leaking mode propagation in an acoustic waveguide (see *Geophys. Abs.* 181-152) is generalized to describe propagation in an elastic halfspace overlain by a liquid layer. The early-arriving PL modes known from earthquake studies are computed for several theoretical models to test the effect of the elastic constants on their dispersion and attenuation, many features of which cannot be predicted by physical reasoning based on harmonic plane wave models. The analogy between PL waves and normal modes in the case treated by Pekeris (see *Geophys. Abs.* 135-10569) is exploited; it is also believed that PL waves are related to an attenuated pseudosurface wave of a free solid halfspace. Late-arriving quasi-standing waves are treated briefly; they may play a role in the propagation of seismic noise in oceanic regions. — D. B. V.

- 185-149. Byatt, W. J., and DeVault, G. P. An iteration-variation method for wave propagation problems: *Jour. Geophys. Research*, v. 66, no. 6, p. 1793-1797, 1961.

In a medium in which the index of refraction varies in one space coordinate only, transform methods are convenient for reducing an inhomogeneous scalar wave equation to an ordinary differential equation in which the square of the space-dependent index of refraction appears explicitly. An iteration-variation method for obtaining approximate expressions for the dispersion relations within the medium is discussed. The ordinary differential equation is converted to an integral equation, the solution of which is begun by iteration. The individual terms in the series thereby formed, which we shall call iterates, then form the basis of a trial function for use in a variational principle. The method is illustrated by an example. — Authors' abstract

- 185-150. Scholte, J. G. J. Propagation of waves in inhomogeneous media: *Geophys. Prosp.*, v. 9, no. 1, p. 87-115, 1961.

A method is developed for determining the propagation of a wave of arbitrary shape in an inhomogeneous medium in which both the density and the velocity change with depth according to an arbitrary continuous function. The solution is obtained by means of successive approximations. The successive terms in this approximation correspond to the direct wave, single reflections, and multiple reflections of successive order. The general formulas are then applied to three particular types of transition layer. — Author's abstract

- 185-151. Hervás Burgos, Pablo. Leyes de propagación de las ondas sísmicas en medios de anomalía elástica [Laws of propagation of seismic waves in elastically anomalous mediums]: *Rev. Geofísica*, v. 19, no. 74, p. 121-169, 1960.

This is a general theoretical study of the propagation of waves in imperfectly elastic mediums. In the first part, the dynamic equations of motion are derived for viscous fluids, firmo-elastic bodies, bodies in the zone of retarded elastic action, plastic bodies, and surface rocks. In the second part, the absorption coefficients and phase velocities for longitudinal and transverse waves in each of these mediums are calculated. The third part analyses seismograms

or spectrums of selected earthquakes in the light of these calculations. It is concluded that the visco-elastic theory explains the phenomena of absorption, dispersion, and hysteresis of terrestrial materials along wave paths. — D.B.V.

- 185-152. Coloma Pérez, Antonio. Sobre el tensor elástico [On the elastic tensor (with English summary)]: *Rev. Geofísica*, v. 19, no. 75, p. 223-226, 1960.

The possibility of deducing the tension tensor is established, given the existence of the elastic tensor, its linear relation with the tensor of pure deformation, as well as the existence of P- and S-waves. Not knowing, a priori, the nature of the elastic tensor, its symmetry is proved. Finally, its expression is worked out and found to coincide with that already known. — Author's summary, D. B. V.

- 185-153. Emura, Kinya. Propagation of the disturbances in the medium consisting of semi-infinite liquid and solid: *Tohoku Univ. Sci. Repts.* ser. 5, v. 12, no. 2, p. 63-100, 1960.

Exact solutions for the two-dimensional propagation of transient disturbances in a medium consisting of a semi-infinite liquid and solid are obtained by means of the Laplace transform techniques developed by Garvin. Approximate solutions for the steady state problem based on the method of saddle points or steepest descent are also given. Disturbances at the surface of the semi-infinite liquid are comparable with those in Lamb's problem, produced by a force acting vertically downward at a line in the surface of the solid in the absence of the liquid. The aspect of the diminution of the refracted wave $P_1P_2P_1$ with distance is different in the exact transient solution from that in the steady state solution.

The modified Rayleigh wave accompanies the disturbance in the liquid as it travels along the surface of the solid with the Rayleigh wave velocity in the absence of liquid, but unlike the Rayleigh wave in Lamb's problem its amplitude decreases with distance along the interface. The accompanying disturbance in the liquid behaves as a refracted wave whose critical angle of incidence is determined by the velocities of sound in the liquid and of the Rayleigh wave in the solid. The sign of particle motion of the reflected wave is reversed for angles of incidence in the ranges 31.6° - 34.7° and 84.6° - 90.0° . — D. B. V.

- 185-154. Takeuchi, Hitoshi, and Saito, Masanori. On the torsional oscillation of the earth (Pt. 2) [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 3, p. 141-149, 1960.

The free periods of torsional oscillations are calculated for two earth models using the variational calculus method. The periods are calculated for a fluid core and for a rigid core assuming (1) a homogeneous mantle and core, and (2) a mantle structure inferred by Jeffreys and Bullen. In the fluid core, the periods are determined also when the coupling between mantle and core is perfect or zero. The observations of free periods must be made with an accuracy of several tens of seconds in order for the information obtained to be of use. (See also *Geophys. Abs.* 178-93.) — V. S. N.

- 185-155. Jobert, N[elly]. Calcul de la dispersion des ondes de Love de grande période à la surface de la Terre [Calculation of the dispersion of long-period Love waves at the surface of the earth (with French, English, and Russian summaries)]: *Annales Géophysique*, v. 16, no. 3, p. 393-413, 1960.

This constitutes the full report on a study of long-period Love wave dispersion previously treated in three short papers published in the Acad. Sci. [Paris] Comptes Rendus, v. 249, no. 11, p. 1014-1016, 1959; v. 250, no. 5, p. 890-892, 1960; and v. 250, no. 22, p. 3693-3695, 1960 (see Geophys. Abs. 179-126, 182-130, 183-157). — D. B. V.

- 185-156. Tazime, Kyozi. Transition from dispersive Rayleigh waves to sound waves in a layer over a half space absolutely rigid: Jour. Physics of Earth [Tokyo], v. 7, no. 1, 1959; reprinted from Hokkaido Univ. Fac. Sci. Jour., ser. 7, v. 1, no. 3, p. 163-179, 1959.

In his investigation of dispersive Rayleigh waves in a layer over a rigid half space, Giese (see Geophys. Abs. 172-68) ignored M_2 waves, assuming that their amplitude was much smaller than that of M_1 waves, nor did he refer to any higher order of M -waves. This paper shows that Giese's assumption concerning the amplitude of M_2 waves is not valid and calculates dispersion curves for various values of Poisson's ratio (σ). The results show that the process of transition from solid to liquid is very complicated. When σ approaches 0.50, the zeroth order of liquid waves consists approximately of many higher orders of $M_n^{(2)}$ -waves, and the first order of liquid waves consists approximately of many higher orders of $M_n^{(1)}$ -waves. — D. B. V.

- 185-157. Suzuki, Ziro, and Sato, Yasuo. Condition for the existence of Love waves in heterogeneous media: Tohoku Univ. Sci. Repts., ser. 5, v. 12, no. 1, p. 36-43, 1960.

In the mathematical deduction of Love waves in heterogeneous mediums, the assumption that density and rigidity tend toward zero or increase indefinitely as depth $z \rightarrow \infty$ leads to the conclusion that there exists a kind of Love wave in which there is no definite relation between velocity and frequency. The existence of these "extraordinary waves" is examined, based on the boundary condition stress=0 at infinite depth; the result is compared with that obtained under the condition displacement=0.

"Extraordinary waves" are introduced when stress=0 but displacement is infinite at $z=\infty$, or conversely, when displacement=0 and stress \neq 0. The condition for eliminating this kind of waves, therefore, is that both stress and displacement must disappear at infinite depth. — D. B. V.

- 185-158. Peselnick, Louis, and Meister, Robert. Acoustic relaxation in chromium: Jour. Geophys. Research, v. 66, no. 6, p. 1957-1961, 1961.

The temperature and frequency dependence of the ultrasonic velocities in polycrystalline chromium from -65°C to +60°C and from 5 to 35 megacycles per sec were measured. The attenuation associated with the dilatational wave was measured at 15 megacycles per sec from -25°C to +25°C. Anomalies in the attenuation and velocity for the dilatational waves were found at -19°C. The compressibility and Poisson's ratio were calculated and from these values the anomalous specific heat was determined. A dispersion in the dilatational velocity was found at -19°C, and the limiting high frequency velocity and relaxation time were estimated on the basis of a single relaxation process. From these calculations the magnitude of the attenuation was predicted; this agreed within a factor of 2 with the measured attenuation. These results are pertinent to the study of phase transitions within the earth. — D. B. V.

- 185-159. Hayakawa, M[asami], and Balakrishna, S. An explanation for the high ultrasonic velocity in Indian rocks: *Geophys. Prosp.*, v. 9, no. 1, p. 74-85, 1961.

In an attempt to explain the high ultrasonic velocities of Indian granites compared to those from other countries, the initial internal pressure and initial velocity at the time of formation of granites have been calculated, using published experimental results on variation of velocity with pressure in Indian, American, Japanese, and Russian rocks. The effect of time of formation at specific depths is also calculated.

Results show that under high pressure (great depth) the process of formation requires more time than at low pressure (shallow depth), and that under high pressure much stress energy can be stored; in other words, initial velocity is higher in rocks formed at great depth than in those formed at shallow depth. The elastic behavior of rocks with pressure thus may provide a clue to their petrogenic history and approximate age. — D. B. V.

- 185-160. Balakrishna, S. Ultrasonic velocities in relation to the degree of metamorphism in limestones: *Indian Acad. Sci. Proc.*, sec. A, v. 50, no. 6, p. 363-365, 1959.

Longitudinal and torsional ultrasonic velocities were measured on a number of Indian limestones using the total internal reflection method. It is concluded from the results, which are tabulated, that in general the ultrasonic velocity increases as the degree of metamorphism increases. Certain fine-grained unmetamorphosed limestones, however, behave like marbles. — D. B. V.

- 185-161. Central Water and Power Research Station Poona. Young's modulus of elasticity for rocks, Head Race tunnel and power house site, Koyna HE project: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona, *Ann. Research Mem.*, p. 216-218, 1959.

Estimates of Young's modulus of elasticity for the rocks constituting the weak zones of tuff breccia in the Head Race and other tunnels of the Koyna hydroelectric project were made in place in order to assess the stress concentrations likely to be encountered in these weak zones under operating conditions. Indirect estimates were made from the compressional wave velocity as measured in place by both the seismic and ultrasonic methods.

Young's moduli for this tuff breccia with zeolites obtained by the seismic method lie between 0.34 and 2.34×10^{11} d per cm^2 , and those obtained by the ultrasonic method between 0.62 and 3.59×10^{11} d per cm^2 . In any particular locality the values obtained by the two methods agree fairly well. The average value of Young's modulus for the tuff breccia with zeolites is 1.80×10^{11} d per cm^2 ; this is about one-fourth the value characteristic of an average massive basalt. Values obtained for all stations are shown in a table. — V. S. N.

- 185-162. Shimozuru, D. Elasticity of rocks and some related geophysical problems: *Japanese Jour. Geophysics*, v. 2, no. 3, 85 p., 1960.

Previous results are reviewed and new results are reported on laboratory measurements of the elasticity of rocks. Wave velocities of rocks are determined and analyzed for the effects of porosity, anisotropy, and temperature.

Results of several hundred laboratory measurements by Shimozuru and others of resonant frequency and of ultrasonic wave velocity are computed and plotted as dilatational (V_p) and shear (V_g) wave velocities versus density. An

empirical expression relating V_p to porosity is evolved from the increase in V_p with density increase observed in measurements on 50 sandstone samples. The effect of anisotropy is found to range from 0 to 5 percent; however, V_p measurements perpendicular and parallel to the bedding of a sandstone differ by 70 percent. Measurements of V_p on samples of granite and dunite at temperatures to 870°C showed a decrease in V_p , but despite a large change between 550°C to 600°C, it is concluded that the data do not support Yoder's hypothesis that a low V_p in the lower crust of the earth is due to the α - β quartz inversion.

A series of high temperature measurements made on hyalopilitic dacite from Usu Volcano showed an anomalous increase in V_p with temperature increase. — E. C. R., V. S. N.

Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean. See Geophys. Abs. 185-587.

185-163. Willis, D[avid] E. Some observations on the attenuation of seismic waves: Earthquake Notes, v. 31, no. 4, p. 37-45, 1960.

Spectral analyses using variable pass-band filters were made on records of a number of quarry blasts recorded on magnetic tape by low frequency seismometers. Empirical equations are derived for P- and surface-waves that describe fairly well the decrease in maximum signal level and the change in vertical ground particle velocity versus frequency as a function of distance. Parameters such as method of firing, depth of burial, or type of rock in which the explosive is detonated are shown to have a significant influence on the spectrums of waves generated by explosive blasts. — V. S. N.

Grachev, Yu. N., Dekhnich, M. Ya., Litvinenko, I. V., Nekrasova, K. A., and Sosnovskaya, A. V. Deep geophysical investigations in the territory of the Baltic shield. See Geophys. Abs. 185-354.

185-164. Lombard, David B. The Hugoniot equation of state of rocks: Univ. California, Lawrence Radiation Lab. Pub., UCRL-6311, 28 p., 1961.

In determining peaceful applications for nuclear explosions detonated underground, it must be possible to predict the effects of the shocks on the surrounding medium. Predictions are based partly on the Hugoniot equation of state. The equations of state of rock salt, granite, tuff, marble, dolomite, limestone, basalt, and other rocks were studied experimentally; measurements were made at pressures ranging from 70 to 900 kb. A comparison of data from limestone and basalt is of particular interest because, despite dissimilar compositions, their equations of state agree well at pressures above 230 kb. An instrument was developed that employs pin-contactors to measure shock velocity and free-surface velocity at locations in a rock medium not far from the explosion. The instrument has performed satisfactorily in tests employing actual nuclear explosions, and it is hoped that stresses from below 100 kb to over 1 mb can be measured. — V. S. N.

ELECTRICAL EXPLORATION

185-165. Roman, Irwin. Apparent resistivity of a single uniform overburden: U.S. Geol. Survey Prof. Paper 365, 99 p., 1960.

The interpretation of resistivity observations can be facilitated by the development of theoretical formulas and corresponding curves. A development

for a single overburden of uniform thickness has been made and formulas derived that involve infinite series. The series have been evaluated for the geophysical case in which the measuring configuration is located on the surface of the earth. A set of curves that can be superimposed on the field observations has been prepared to permit direct determination of the resistivity and thickness of the overburden, and the resistivity of the underlying medium. Auxiliary tables are given to simplify the numerical evaluations for configurations not covered by the prepared curves. — Author's abstract

- 185-166. Cook, Kenneth L., and Gray, Russell L. Theoretical horizontal resistivity profiles over hemispherical sinks: *Geophysics*, v. 26, no. 3, p. 342-354, 1961.

An album of 40 sets (about 200 different curves) of theoretical horizontal resistivity profiles over and near outcropping hemispherical sinks (a few samples of which are reproduced here) shows the effects of sink diameter, reflection factor k , and distance of the traverse from the center of the sink on the magnitude and shape of the apparent resistivity curves. Values of apparent resistivity for both Lee and Wenner configurations were computed, using a digital computer. In general, the larger the sink, the larger the magnitude of the apparent resistivity anomaly up to a sink diameter of about $8a$ (a =electrode separation), for which diameter the apparent resistivity over the central part of the sink is essentially equal to the resistivity of the sink irrespective of the reflection factor. For sink diameters equal to a , large apparent resistivity anomalies result from "pseudofocusing" effects. The major peaks for the apparent resistivity curves can be used to detect the edges of sinks. The album is also of general use in qualitative interpretation of resistivity anomalies over other features such as faults (for large sinks), dikes, and grabens. — D. B. V.

- 185-167. Wait, James R. Propagation of electromagnetic pulses in a homogeneous conducting earth: *Appl. Sci. Research*, sec. B, v. 8, no. 3, p. 213-252, 1960.

A general analysis for the electromagnetic response of conducting mediums due to pulse excitation is presented. The treatment is based on the Laplace transform theory. After a survey of previous work, pointing out its scope and limitations, the theory of propagation of a plane wave pulse in an infinite homogeneous conducting medium is reviewed. The relative importance of the conductivity and dielectric constant can be evaluated from the form of these results.

For sufficiently large times in the transient response, displacement currents may safely be neglected for sea water and most geological mediums. Under this assumption, the waveform of the electric field in a conducting medium is illustrated for the case where the source is an electric dipole energized by a step-function current; results are also presented for exponential and bell-shaped source functions. The pulse shape of the field components is profoundly modified as they propagate through the medium. It is suggested that this property may be utilized in measuring distances in the earth's crust.

The more difficult problem of propagation in noninfinite conducting mediums is also considered. An involved analytical expression for the transient fields is required to account for the presence of the interface in a conducting half space (homogeneous flat ground). Certain special cases, such as a horizontal electric dipole at the interface, are illustrated numerically. The transient excitation of a wire loop lying on the surface of a homogeneous ground is also considered. Finally, a transient coupling between pairs of parallel insulated wires grounded at their end points is treated as an extension of the earlier results. — D. B. V.

- 185-168. Frankena, H. J. Transient phenomena associated with Sommerfeld's horizontal dipole problem: *Appl. Sci. Research, sec. B*, v. 8, no. 4, p. 357-368, 1960.

A horizontal electric dipole, located above the plane interface of two non-conducting mediums, has a dipole moment which is an arbitrary but given function of time when $t > 0$ and which is zero when $t < 0$. Traveling electromagnetic waves, generated by this dipole, are calculated with the aid of a modification of Cagniard's method. For the electric field vector above and at the interface we obtain expressions for the direct and reflected waves in the case that the velocity of light in the medium containing the source is the larger one. — Author's summary

- 185-169. de Hoop, A. T., and Frankena, H. J. Radiation of pulses generated by a vertical electric dipole above a plane, non-conducting, earth: *Appl. Sci. Research, sec. B*, v. 8, no. 4, p. 369-377, 1960.

A technique developed by de Hoop, based on his simplification of Cagniard's method (see *Geophys. Abs.* 184-219), is used here to determine the electromagnetic field radiated by a vertical electric dipole located at a height h above a plane nonconducting earth. Attention is confined to the field in the air; unless $h=0$, determination of the field in the earth is much more difficult. The result is given in the form of a definite integral over a finite interval; this integral can easily be computed numerically. — D. B. V.

- 185-170. Senior, T. B. A. Impedance boundary conditions for imperfectly conducting surfaces: *Appl. Sci. Research, sec. B*, v. 8, no. 5-6, p. 418-436, 1960.

It is shown how the exact electromagnetic boundary conditions at the surface of a material of large refractive index can be approximated to yield the usual impedance or Leontovich boundary conditions. These conditions relate the tangential components of the electric and magnetic fields (or normal components of their normal derivatives) via a surface impedance which is a function only of the electromagnetic properties of the material. They are valid for surfaces whose radii of curvature are large compared with the penetration depth, and also for materials which are not homogeneous but whose properties vary slowly from point to point. As the refractive index (or conductivity) increases to infinity, the conditions go over uniformly to the conditions for perfect conductivity. — Author's abstract

- 185-171. Senior, T. B. A. Impedance boundary conditions for statistically rough surfaces: *Appl. Sci. Research, sec. B*, v. 8, no. 5-6, p. 437-462, 1960.

It is shown that for an electromagnetic field incident on a perfectly conducting surface having small geometrical irregularities which are distributed at random but in a statistically uniform and isotropic manner, the boundary condition can be replaced by a generalized impedance condition applied at a neighboring mean surface. The boundary condition is applicable to curved surfaces providing the radii of curvature are large in comparison with the wavelength. This approach is of value in studying the effect of minor surface roughness on scattering of electromagnetic waves. — V. S. N.

- 185-172. Kertz, Walter. Leitungsfähiger Zylinder im transversalen magnetischen Wechselfeld [Conducting cylinder in the transverse alternating magnetic field (with English summary)]: *Gerlands Beitr. Geophysik*, v. 69, no. 1, p. 4-28, 1960.

The distribution and magnetic field of the electric currents induced when an infinite cylinder is acted on by a two-dimensional transverse magnetic field are analyzed and found to be functions of the frequency of the alternating magnetic field, the conductivity, and the radius of the cylinder. The study is pertinent to problems of geomagnetic variations and to interpretation of electrical exploration data obtained by alternating current procedures. — D. B. V.

- 185-173. Orellana Silva, Ernesto. Algunas cuestiones de prospección geoelectrica [Some questions of geoelectrical prospecting]: Rev. Geofísica, v. 19, no. 73, p. 13-28, 1960.

The choice of electrical methods suitable for a given area is much wider than in the case of gravimetric or magnetic prospecting and should be based on thorough knowledge and ample experience in interpretation. The penetration achieved by different techniques, particularly by various electrode configurations, and the significance of empirical methods of interpretation are discussed at some length. In comparison with interpretations based on the use of standard theoretical curves, those based on empirical methods often give erroneous results. Certain methods using fixed current electrodes can use the same set of standard curves as other methods using movable current electrodes; examples of this correspondence are given. In general, resistivity methods are found preferable for vertical investigations and potential methods for lateral investigations. — D. B. V.

- 185-174. Vedrintsev, G. A. K teorii elektricheskikh zondirovaniy v usloviyakh gorizonta'ln'o-neodnorodnykh sred [Theory of electrical sounding under conditions of horizontal heterogeneous mediums]: Vyssh. Ucheb. Zavedeniy Izv., Geologiya i Razvedka, no. 5, p. 125-127, 1960.

In connection with investigations of the electric field of a direct current in a vertically layered medium underlain by an insulator or by an absolute conductor at a depth h by means of integration of a LePlace equation, an expression was obtained in a general form for potentials created by points and dipole sources at any point on the surface of a cross-section. As a product of the investigations, formulas were obtained by which theoretical curves were constructed for various types of probes. A total of 150 curves were calculated, of which 2 are illustrated. — J. W. C.

- 185-175. Nikitina, V. N. K difraktsii na poluploskosti v pogloshchayushchikh sredakh [On diffraction at a half-plane in absorbing mediums]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1442-1449, 1960.

The problem of diffraction of electromagnetic waves at the edge of a half-plane in a homogeneous conducting medium is discussed. The branched function of a plane wave for a complex wave number is investigated on the basis of the Sommerfeld's theory of branched functions, and the diffracted electromagnetic field is constructed. The relative intensity of the diffracted electric field is studied in terms of the absorption properties of the medium. The investigation is intended for application to diffraction of an alternating electromagnetic field at the edge of an ore body. — A. J. S.

- 185-176. Kozulin, Yu. N. Elektromagnitnoye pole izluchatelya pri bol'shikh parametrah [The electromagnetic field of an emitter for large parameters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1504-1506, 1960.

This is a study of the behavior of the electromagnetic field of an emitter located on the surface of a horizontally layered structure having a large modulus value p , which is the product of the complex wave number for the upper layer of the medium times the spread of the arrangement in electromagnetic sounding by the frequency method. The components of the dimensionless electromagnetic field of a vertical magnetic dipole, located on the surface of a many-layered medium, are represented by a series of integrals which for large values of p are approximated by finite sums in terms of functions. The application of the formulas derived to interpretations of field data obtained by the frequency method of electromagnetic sounding of two- and three-layered mediums shows a satisfactory agreement with the theory. — A. J. S.

- 185-177. Shaub, Yu. B. O napravlennoy priyeme vtorichnykh signalov v elektrorazvedke metodom vrashchayushchegosya magnitnogo polya [On the directed reception of secondary signals in electrical exploration by the rotating magnetic field method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1608-1611, 1960.

Directed reception of secondary signals of a rotating magnetic field is analyzed, and diagrams for directional determination of various parameters are plotted. Formulas are derived for the active and reactive components of the disbalancing signal (four-leaf rose graphs 45° different in phase), for the modulus of the signal (graph is a circle), and for the phase of the signal (graph is a cardioid). The derivation of direction diagrams allows directed reception in surface and borehole electrical exploration. — A. J. S.

- 185-178. Hayashi, Yoshio. Perturbation theory of the electromagnetic fields in anisotropic inhomogeneous media: Japan Acad. Proc., v. 36; no. 9, p. 547-549, 1960.

A mathematical analysis is presented of the electromagnetic fields in anisotropic inhomogeneous mediums. A simple, rigorous, and general development of the perturbation theory of the fields is made with the assumption that the deviations of the anisotropy and inhomogeneity are not large. — V. S. N.

- 185-179. Hayashi, Yoshio. General analyses of the forced oscillations in a wave-guide and in a cavity: Japan Acad. Proc., v. 36, no. 9, p. 550-554, 1960.

Mathematical analyses are made of the equations $\nabla \times \mathbf{E} = -i\omega \mu \mathbf{H}$ and $\nabla \times \mathbf{H} = (\sigma + i\omega \epsilon) \mathbf{E} + \mathbf{k}_E$ that satisfy the electromagnetic fields \mathbf{E} and \mathbf{H} in a homogeneous and isotropic medium with medium constants ϵ , μ and σ , and also satisfy the fields in an anisotropic medium, discussed from the view point of perturbation theory, in which \mathbf{k}_E and \mathbf{k}_H are the perturbed terms. Analyses of fields in a waveguide the axis of which is parallel to the z axis, in a cavity which is a finite domain enclosed by a waveguide and two planes of conductors perpendicular to the axis of the waveguide, in a circular waveguide, and in several other mediums are given. — V. S. N.

- 185-180. Lyu, Sin-Khan. Depth of prospecting of an ellipsoid of rotation with the method of isolines [in Chinese with Russian summary]: Acta Geophys. Sinica, v. 7, no. 2, p. 108-115, 1958.

A study was made of anomalies in potential of a uniform polarizing ellipsoid of rotation in a field of uniform current. A rule is found for the change in these anomalies with changes in depth of the ellipsoid; this rule is analyzed, and it is demonstrated to what depth the method of isolines is effective. — J. W. C.

- 185-181. Burr, S. V. The self-potential method for the prospector: Canadian Mining Metall. Bull., v. 53, no. 583, p. 866-872, 1960; also in Canadian Inst. Mining Metallurgy Trans., v. 63, p. 590-596, 1960.

The self-potential method is advocated here as the most rapid and economical geophysical method for ground reconnaissance over areas suspected of having good conductors, or to detail known conductors. The history, recommended equipment and prospecting procedure, and limitations and advantages of the method are discussed. The method can save heavy drilling costs by detecting the presence of graphite and indicating whether the conductor may be exposed easily for examination. Several prospected areas in northern Quebec are cited as examples of application of the method. — V. S. N.

- 185-182. Porstendorfer, G[ottfried]. Versuche zur Ausnützung vagabundierender Ströme in der geophysikalischen Prospektion [Experiments with the use of stray currents in geophysical prospecting (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 128-143, 1961.

Experimental recording of the three components of the diurnal intensity of stray industrial currents in a mine shaft outside the area of mining activity at Freiberg showed the uninterrupted presence of such currents with periods ranging from a few minutes to a few hours. It is demonstrated theoretically and by model experiments that these currents can be used for prospecting purposes when the ratio between the distance from their source and the size of the surveyed area exceeds a critical value that depends on the accuracy of the measurements. Classic telluric measuring techniques must be replaced by a vectorial recording method in order to make the procedure economically feasible.

A field example from a vein deposit shows that stray currents of random direction and also earth currents are channeled by veins of anomalous conductivity. Other examples are given of underground measurement of stray currents. — D. B. V.

- 185-183. Paczyński, Bronisław. Stosowanie metody potencjałów własnych dla określenia parametrów hydrogeologicznych przy próbnym pompowaniu [Use of the self-potential method for determination of hydrogeologic parameters in test pumping (with English summary)]: Przegląd Geol. v. 9, no. 4, p. 210-214, 1961.

Use of the self-potential method in geological investigations of ground water is generally limited to determination of the direction of flow in undisturbed circulation systems. On the basis of theoretical considerations and field experiments there is the possibility of using this method to study artificially produced forms of ground water level such as depression cones and distribution of liquid during water-flooding of wells. Several examples are given of the use of the self-potential method under conditions of a disturbed ground water regimen. — J. W. C.

- 185-184. Tretyak, O. N. Zastosuvannya metodu kombinovanoho elektroprofiluvannya pry rozshukakh zon tektonichnykh porushen' [Application of the method of combined electrical profiling in investigations of zones of tectonic disturbances]: Akad. Nauk Ukrainy. RSR Heol. Zhur., v. 20, no. 3, p. 72-76, 1960.

Combined electrical profiling under various geologic conditions in the Transcarpathian region in 1952-57 is described. The combined 3-electrode

set-up, one of the most sensitive profiling methods, is particularly valuable in the folded areas of mountainous regions where local bodies have a very small horizontal extent (0.5-5 m). The character of the resistivity anomalies obtained by this method over zones of tectonic disturbance (such as mineralized fractures in crystalline rocks, igneous intrusions in sections of sedimentary and pyroclastic rocks, and easily deformed argillaceous sediments) was found to be very intimately related to their origin, form, and attitude. With an electrode configuration of the type AA'MNC $\rightarrow \infty$, BB'NMC $\rightarrow \infty$, not only the existence but also the direction of dip of a disturbing body could be established. — D. B. V.

- 185-185. Kunori, Shoichi, and Yokoyama, Hidekichi. Experimental studies for electromagnetic prospecting (pt. 2) [in Japanese with English abstract]: Tohoku Kozan, v. 7, no. 1, p. 9-14, 1960.

Some model experimental results of "in-phase" and "out-of-phase" variations of the secondary magnetic field induced by the two-coil method are described. These results are applicable to the interpretation of data from field surveys using the electromagnetic method. (See also Geophys. Abs. 183-230.) — V.S.N.

- 185-186. Bergmann, H. J. Horizontal loop equipment in ground survey: Canadian Mining Jour., v. 81, no. 12, p. 57-61, 1960.

A brief description of the Ronka horizontal loop electromagnetic equipment and its field operation is given. By measuring the two components of the secondary field with this instrument it is possible to obtain a measure of the relative conductivity and in many cases to discriminate between conductors of different characteristics. It is also possible to distinguish between the responses from topographical effects and those from a conductive body. Information may be obtained on dip, width, and depth of the conductors. The equipment is particularly well adapted for ground surveys following an airborne survey because of its mobility and readily interpretable results; data may be interpreted in the field. — V. S. N.

- 185-187. Bobrovnikov, L. Z. K teorii usiliteley postoyannogo toka s elektromekhanicheskim preobrazovatelem [To the theory of d-c amplifiers with an electromechanical converter]: Prikladnaya Geofizika, no. 26, p. 78-89, 1960.

A broad-band d-c amplifier based on the principle of accumulation of signal strength in the incoming circuit is discussed and analyzed mathematically. The analysis used in the magnetic stabilization method is valid for signals with frequencies much lower than the conversion frequency. At high frequencies the signal becomes quantized, leading to lower amplification; in this case the transmission coefficient of the incoming circuit must be modified to discount the quantization. — A. J. S.

- 185-188. King, A[nthony] J. Geophysical investigations at Manyeghi hot springs: Tanganyika Geol. Survey Recs., v. 8 (1958), p. 99-104, 1960.

A brief account is given of preliminary electromagnetic potential-drop-ratio, and resistivity surveys carried out at Manyeghi, Singida district, Tanganyika. The geophysical methods proved inadequate in locating structures that control the helium-bearing springs because of the abnormally low surface resistivities which prevent effective penetration of either direct or alternating current. It is concluded that reliance must be placed on exploratory drilling. — V. S. N.

- 185-189. Lerici, Carlo Maurilio. Esplorazione geofisica nella zona archeologica di Sibari [Geophysical exploration in the Sybaris archaeological area (with English, French, and German summaries)]: *Ricerca Sci.*, v. 30, no. 8, p. 1107-1145, 1960.

Resistivity sounding and profiling were used in conjunction with aerial photographs and drilling in the plain of Crati in Italy in the search for archaeological sites, particularly of the city of Sybaris. The methods and techniques used are described. Two zones of interest were found. The horizontal electrical measurements proved to be most useful. — D. B. V.

- 185-190. Pomper, Johannes, and Fröhlich, Lothar. Einsatz der Geoelektrik zur Erkundung glazialdynamisch gestörter Tone [Extension of electrical surveying to the investigation of glaciodynamically deformed clays (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 8, p. 387-390, 1960.

Owing to extensive deformation of the clay deposits in the Bad Schmiedeberg area of East Germany by glacier action, a borehole spacing of 50 m was required for demonstrating B reserves for the stoneware industry. When the electrical resistivity method (Wenner configuration) was used in conjunction with drilling in some of the larger survey areas, a 100-m borehole spacing was found to be adequate. The cost of exploration by drilling alone was three times greater per unit area than that of a combined electrical and drilling program. — D. B. V.

- 185-191. Braekken, H. Deep ore exploration by electrical methods. Some experiments and developments (with discussion): *Geophys. Prosp.*, v. 9, no. 1, p. 144-162, 1961.

Under favorable conditions, such as exist in parts of Norway, electrical and electromagnetic surveys may penetrate to great depths. An ore body extending downward from 700 m, separated from but representing the continuation of a body that ended at 500 m, was located by surface measurements using a frequency of 500 cycles per second and was traced over a considerable distance by further electromagnetic measurements at the surface in which the energizing current was fed directly to the ore in drill holes. Possibilities, problems, and further improvements in deep electromagnetic techniques and interpretation are discussed. The electromagnetic results were confirmed by d-c equipotential mapping at the surface, with the current fed directly to the ore. Problems and developments in such deep charged potential prospecting techniques and interpretations are also discussed. — D. B. V.

- 185-192. Sarma, V. V. Jagannadha. Electrical resistivity investigations along Jaggannapeta-Bodasakurru Road—East Godavary Dt: India Natl. Inst. Sci. Proc., v. 26, pt. A, no. 6, p. 587-591, 1960.

A geological cross section along the Jaggannapeta-Bodasakurru road based on results of an electrical resistivity survey of the area is presented. The cross section confirms the observation that the course of the Godavary River at Bodasakurru has shifted from a previous course near Nagaram. The electrical resistivity results also indicate the presence of a layer highly saturated with saline water. — V. S. N.

Central Water and Power Research Station Poona. Geophysical investigations at Mohana dam site. See *Geophys. Abs.* 185-559.

- 185-193. Akimov, A. T. Rezul'taty merzlotno-geofizicheskikh issledovaniy v vostochnoy chasti Bol'shezemel'skoy tundry [Results of permafrost-geophysical investigations in the eastern part of the Bol'shaya Zemlya tundra]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 5-46, 1959.

Electrical and geochemical studies made both in the laboratory and in the field in the vicinity of Vorkuta in the northwestern Siberian tundra are reported. The permafrost ranges from 0 to 200 m in thickness, and the temperature is not below -2°C ; thawed areas are dispersed among the frozen areas. Isore-sistivity maps are presented. — A. J. S.

- 185-194. Dostovalov, B. N. Merzlotnaya s'emka metodom soprotivleniy v usloviyakh Severo-Zapadnoy Sibiri [Cryological survey by the resistivity method under the conditions of northwestern Siberia]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 47-80, 1959.

An electrical survey was made of the permafrost in the Poluy River region of Siberia in 1948. The geology and physical geography are discussed on the basis of the results of this survey. The margins of the permafrost were clearly outlined by the survey, and thickness determinations were possible in some places. — A. J. S.

- 185-195. Dostovalov, B. N. Issledovaniye merzlykh porod metodom soprotivleniy v nizov'yakh r. Indigirki [Permafrost investigation by the resistivity method in the lower reaches of the Indigirka River]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 81-112, 1959.

Resistivity investigations of the permafrost in the region of the lower reaches of the Indigirka River are reported; the procedures are described in detail. A geocryological analysis of the region is also given. — A. J. S.

- 185-196. Yakupov, V. S. Opredeleniye moshchnosti sovremennykh rykhlykh otlozheniy metodom vertikal'nogo elektricheskogo zondirovaniya v rayonakh s nizkoy temperaturoy mnogoletnemerzlykh porod [Determination of thickness of contemporary friable deposits by the method of vertical electric sounding in regions of low temperature permafrost]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 144-183, 1959.

Geologic profiles were constructed for permafrost, taking advantage of the fact that frozen friable material has a much higher electrical resistivity than does an underlying sandstone or shale. A method is developed for determining thickness of permafrost in regions of minus 2°C - 3°C . — A. J. S.

- 185-197. Polishchuk, N. K., Filosofov, G. N., and Balobayev, V. T. Usloviya zaleganiya merzlykh porod v Chul'manskom rayone po dannym elektrometricheskikh izmereniy [Deposition conditions of frozen rocks in the Chul'man region according to electrometric measurements]: Akad. Nauk SSSR, Inst. Merzlotovedeniye Trudy, v. 15, p. 184-193, 1959.

The outline of the permafrost area in the Chul'man coal district of the Aldan mining region was determined by vertical electrical sounding. Thickness determinations were not possible due to unknown variations in the water content of the rocks. — A. J. S.

- 185-198. Gaskell, T[homas] F., and Threadgold, P. Borehole surveying, in Methods and techniques in geophysics, v. 1: New York, Interscience Publishers, Inc., p. 62-103, 1960.

An historical summary of electrical well logging is given, and a discussion of the rock formation characteristics—electrical resistivity, natural and induced radioactivity, and acoustic wave velocity—and of the effects of the presence of the borehole is presented as an introduction to the principles and applications of various logging devices. The microlog, microlaterolog, neutron-gamma log, focused-current devices, and radioactive measurements are described, and their use in estimating porosity and relative fluid contents of the reservoir rocks as well as in assessing the flow characteristics of the reservoir rocks is discussed. Additional borehole measurements at present not used directly in hydrocarbon estimation—continuous velocity logging, measurement of strata dip, temperature logs, and pressure measurements—are described briefly. In conclusion a discussion of possible future developments is presented. Technical problems of drilling to the M-discontinuity are considered in a brief appendix. — V. S. N.

- 185-199. Threadgold, P. Advances in well logging: Inst. Petroleum Rev., v. 14, no. 168, p. 389-391, 1960.

Well logging, although introduced in the 1920's, was not accepted as a routine field tool until Archie (1942) worked out the basic equations relating resistivity of porous strata to relative fluid saturations of the strata. The next fundamental development was that of Doll and Wyllie (1943) on the elucidation of the spontaneous potential curve. Since that time numerous advances in instrumental techniques have been made, but none represents a fundamentally new development. The various logging methods are reviewed, and possibilities for future developments are discussed. It is suggested that computer techniques will be applied to well logging and make it possible to replace the log with direct interpretations from computers at the wellhead. — V. S. N.

- 185-200. Duersterhoeft, W. C., Jr. Propagation effects in induction logging: Geophysics, v. 26, no. 2, p. 192-204, 1961.

Induction logging utilizes the component of induced receiver coil voltage that is in phase with transmitter coil current as a measure of the conductivity of material surrounding the coils. This paper considers the problem of the field of a vertical magnetic dipole in a horizontally stratified, isotropic conductive formation and shows the receiver coil voltage can be considered as composed of responses due to electromagnetic waves in the formation. These waves which experience attenuation and phase shift as they propagate in the formation are reflected at each interface encountered, and a component of receiver coil voltage is induced for each passage of a wave. The relation of the receiver coil voltage components to the geometric factor of previous analysis is discussed. Universal curves that are useful in determining the response due to unreflected primary and reflected secondary waves are presented. Example induction log system responses based on the analysis of the present paper are presented. — Author's abstract

- 185-201. Henkel, J[ohn] H., and Collins, T. C. Induced polarization in electrolyte saturated earth plugs: Geophysics, v. 26, no. 2, p. 205-210, 1961.

This paper describes the results of some studies of the dependence of induced polarization and of the formation resistivity factor upon solution concentration in saturated porous plugs. Two theories based upon two different

simple models are developed. The first treats induced polarization as an electric dipole polarization occurring at the surface of clay particles. It is a relaxation theory that does not lead to results agreeable with experiments. The second theory treats induced polarization as a concentration polarization which is induced at solution-clay surfaces when current flows across the surfaces. The second theory is more successful than the first in two ways: (1) it leads to a time dependence more consistent with the experimental decays; (2) it leads to equations involving the resistivity of the saturating solution ρ_s which are also more consistent with experiments. — Authors' abstract

- 185-202. Lishman, J. R. Salt bed identification from unfocused resistivity logs: *Geophysics*, v. 26, no. 3, p. 320-341, 1961.

Salt beds have almost infinite electrical resistivity. They differ from other infinitely resistive beds in that they are usually soluble in drilling fluids, and give rise to enlarged boreholes. An infinitely resistive bed lying between shales may be recognized from the characteristic shape of the electric log resistivity curves and ratios of their readings. Any one of the curves may then be used to compute the borehole diameter, and hence decide whether the bed is salt. Where a washed out salt bed is adjacent to another infinitely resistive bed in which the borehole is to gauge, the configuration of the curves is very characteristic. Apparent resistivity ratios again help to identify the salt. — Author's abstract

- 185-203. Walker, Terry. Simplified log interpretation: *Petroleum Engineer*, v. 32, no. 5, p. B90-95, B99-100 (pt. 1); *ibid.*, no. 6, p. B66, B69, B75, B78, B82, B88 (pt. 2); *ibid.*, no. 9, p. B70, B74, B78-79 (pt. 3), 1960.

Saturation determinations require two primary measurements from logs—true resistivity and porosity. The simplified logging technique presented in this series of papers is based upon the focused devices, and each measurement comes from just one curve with little or no correction required and permits interpretation without laborious calculations from equations.

In parts 1 and 2, the means of simplifying the proper choice of logging tools and the interpretation of the induction or guard tools used in conjunction with the FoRxo tool are discussed. The characteristics of the guard and induction tools and the area of application of each are treated in detail. Simplified saturation charts to be used for calculation of induction and guard logs are presented in part 2, and field examples of induction- and guard-FoRxo combination logs discussed.

In part 3 the applications of a radioactive logging device in radiation-induction logging are discussed. Radiation-induction and radiation-guard saturation charts are presented for use in obtaining quick readings in deep investigations. — V. S. N.

- 185-204. Burjakowski [Buryakovskiy], L. A. Permeabilitätsbestimmung mit Hilfe der Widerstandskarottage [Permeability determination by means of resistivity logging]: *Zeitschr. Angew. Geologie*, v. 6, no. 3, p. 112-114, 1960.

This is a German version of a paper published in *Geologiya Nefti i Gaza*, no. 1, p. 47-51, 1959 (see *Geophys. Abs.* 184-299). — D. B. V.

- 185-205. Lehnert, Klaus. Einige Besonderheiten konventioneller elektrischer Bohrlochmesskurven in "hartem" Gebirge [Some features of conventional electric logs in "hard" rock (with English and Russian summaries)]: Zeitschr. Angew. Geologie, v. 6, no. 5, p. 207-210, 1960.

Quantitative interpretation of conventional resistivity logs obtained with normal and lateral devices is impossible in "hard" rocks (defined as those in which the resistivity is several times higher than in normal sandy-clayey sediment), and adequate qualitative results are possible only in some cases. Nevertheless, certain information concerning porous and permeable zones may be deduced from these logs, in addition to their use for correlation purposes, if the characteristic shape and major kicks of the curve are known. In many cases information can no longer be obtained by modern logging methods because the holes have been cased or flooded since the conventional logs were run. Examples from Thuringia are given in illustration. — D. B. V.

- 185-206. Fujiwara, Chuichi. Studies on electrical well log analysis (pt. 3): Tohoku Kozan, v. 7, no. 2, p. 49-53, 1960.

This is a continuation of studies on fundamental problems in electrical well-log analysis (see Geophys. Abs. 183-263). In this part the experimental relation between resistivity and SP is discussed. — V. S. N.

- 185-207. Holz, Peter. New electronic instrument to survey boreholes: Canadian Mining Jour., v. 82, no. 1, p. 45-46, 1961.

A new transistorized electronic instrument for surveying deep boreholes, designed and built in South Africa, is described. The instrument provides all required information instantly, any number of readings may be taken at varying depths, and changes of angle and direction are calculated rapidly. Basically the instrument consists of a stable radio frequency oscillator and an amplifier connected by cable to a console at the surface of the ground. Other components are a carriage, pendulum, compass needle with a shortened "south pole," light source, tuning condenser, and photo-transistor. Movements of the pendulum alter the setting of the tuning condenser attached to it, and the signal transmitting to the surface changes in frequency. — V. S. N.

- 185-208. Rollo, J. R. Ground water in Louisiana: Louisiana Dept. Conservation, Geol. Survey and Dept. Public Works Water Resources Bull., no. 1, 84 p., 1960.

The general availability of ground water throughout Louisiana is discussed for the use of those responsible for the development of ground-water resources. The use of electric logs in ground-water and geologic investigations especially as a basis for distinguishing between fresh and salt water is summarized, the subsurface geology is reviewed, and the occurrence of fresh ground water is discussed and illustrated. Data used are primarily from electrical logs, chemical analyses, records of wells, and geologic and ground-water reports. — V. S. N.

- 185-209. McCrossan, R. G. Resistivity mapping and petrophysical study of Upper Devonian inter-reef calcareous shales of central Alberta, Canada: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 4, p. 441-470, 1961.

A resistivity map of the inter-reef deposits in the Woodbend group in Alberta shows haloes of high resistivity around the reefs which seem to be related to an increased calcareous content in the dominantly argillaceous section. In order to evaluate this map, the carbonate content and porosity of numerous core samples were determined and compared with resistivity logs. The rocks were also examined petrographically.

A linear relation was found between carbonate content and porosity, suggesting that reduction of porosity is directly proportional to the volume of carbonate grains present. Porosity varies inversely and resistivity directly with depth and carbonate content. Rocks high in organic matter are less porous and more resistant than nonorganic rocks, for the same carbonate content and depth.

Although not linear, the relation between carbonate content and resistivity is very useful. Subsurface mapping from resistivity logs should prove to be a valuable exploration tool for following the distribution of bulky mineral grains in shale. (See also *Geophys. Abs.* 180-143.) — D. B. V.

- 185-210. Gallup, W. B. Current exploratory techniques in the Athabasca bituminous sands area: *Canadian Mining Metall. Bull.*, v. 53, no. 576, p. 245-249, 1960; *Canadian Inst. Mining Metallurgy Trans.*, v. 63, p. 157-161, 1960.

The Athabasca bituminous sands, which occur along the Athabasca River in the vicinity of Fort McMurray and Fort MacKay, have been subject to sporadic investigations since the beginning of the century. Current exploratory techniques involve a moderate amount of drilling and coring followed by electric and radioactivity logging of most holes. Cores are analyzed for bitumen by weight and percentage of connate water; this analysis is used for calibration of the logs which are then interpreted to give a qualitative analysis more accurate than that from the cores. Bitumen saturation is deduced from the resistivity as shown by the laterologs. A saturation in excess of 10 percent bitumen by weight is set arbitrarily as being of economic interest. Radioactivity logs are used to eliminate shaly and tight sand sections. — V. S. N.

- 195-211. Rodiger, Kurt. Analyse der Salzstock-Hebungen mit Hilfe elektrischer Bohrlochmessungen, dargestellt an den Salzstocken Bramstedt und Etzel [Analysis of salt dome uplifts with the aid of electric logging, as shown at the Bramstedt and Etzel salt domes]: *Erdöl u. Kohle*, v. 13, no. 3, p. 149-153, 1960.

In order to determine whether salt domes are formed all at once during an orogenic phase or by continuous movement linked to the physical properties of salt (halokinesis), it is necessary to analyze the salt dome formation process quantitatively. An attempt is made in this direction, using electric logging measurements to analyze the movements that have taken place in the vicinity of two salt domes in north Germany, the Bramstedt oilfield in the southern part of the east flank of the Bramstedt-Neumünster salt dome and the Etzel oilfield in the northwest part of the Etzel salt dome.

As the drill holes are distributed over an area, the resistivity and SP logs can be used to give curves representing the thickness of each stratigraphic unit. Movements are reconstructed from the percentage and direction of decrease in thickness of each group.

In both oilfields, salt dome uplift is shown to have been continuous throughout Cretaceous and Tertiary time, although intensified during the four orogenic phases that are reflected in the sedimentary record (Late Cimmerian, Subhercynian, Laramide, and Pyrenean). The halokinesis theory is thus corroborated. — D. B. V.

- 185-212. Oilweek. Geophysicists ponder crisis in exploration activity: Oilweek, v. 12, no. 3, p. 41, 44-46, 48-50, 52-53, 1961.

Abstracts are given for papers presented by M. B. Dobrin, D. M. E. McLarty, J. P. Woods, T. A. Link, W. T. Born, P. L. Lyons, C. M. Moore, D. C. Jones, F. A. Van Melle, L. R. Newfarmer, Colin Campbell, J. C. Hollister, and N. R. Paterson at a one-day symposium, "Exploration geophysics—today and tomorrow," at Calgary, Alberta. Geophysical activity in North America has declined 50 percent in the past eight years. Seismograph crews operating in the United States declined from 655 in 1952 to 425 in 1959; gravity crews declined from 160 to 45. In Canada, seismic crews dropped from 153 in 1952 to 67 in 1959. Nearly all experts at the symposium agreed that exploration activity will increase in view of large additional reserves needed to meet the steadily growing world demand. All warned that to increase or even maintain exploration efforts in North America, new reserves must be found at costs that are competitive with alternate sources of oil, such as secondary recovery, tar and shales, and from increased foreign imports. — V. S. N.

- 185-213. World Oil. How closely is U. S. wildcat drilling controlled by seismograph?: World Oil, v. 152, no. 5, p. 72, 1961.

The number of wildcat wells drilled in any year is greatly influenced by the amount of seismic work done four years previously. Exploration drilling appears to be destined for a decline over the next four years provided that new methods of direct explorations do not change the current trend. — J. W. C.

- 185-214. Oil in Canada. Geophysical work up 43.5 percent in month: Oil in Canada, v. 13, no. 12, p. 18, 1961.

Geophysical activity in western Canada at mid-January showed an increase of 43.5 percent over December but was down 9.2 percent from last January. A total of 85 seismograph crews and 4 gravimeter crews were active—30 in British Columbia, 49 in Alberta, 1 in Saskatchewan, and 9 in the Northwest Territories. — V. S. N.

- 185-215. Finsterwalder, Richard. Polarforschung und Internationale Glaziologische Grönland-Expedition 1957/60 [Polar research and International Glaciological Greenland Expedition of 1957-60]: Bayerische Akad. Wiss. Sitzungsber. Math.-Naturw. Kl., v. 1958, p. 37-50, 1958.

The objectives of the Greenland expedition of 1957-60 are outlined. The main task was the construction of a geodetic-geophysical transverse profile across the center of Greenland from Disko Bay to Cecilia Nunatak, supplemented by a north-south profile on the west flank of the ice cap about 50 km from the coast. Geophysical projects include seismic and gravimetric determinations of ice thickness and bedrock topography, and temperature measurements in the ice (see also Geophys. Abs. 185-299). — D. B. V.

- 185-216. Facsínay, László, and Mészáros, Mihály. A perkupai gipsz-anhidrit terület geofizikai újraértékelése [Geophysical reevaluation of the Perkupa gypsum-anhydrite area (with English and Russian summaries)]: Geofiz. Közlemények, v. 8, no. 4, p. 151-176, 1960.

Geophysical investigations in the Perkupa area of Hungary since 1920 are reviewed and the results compared with the geologic evidence. Recommendations are made for additional magnetic and gravity measurements and electrical test measurements. — D. B. V.

- 185-217. Lányi, János. A Magyar Kisalföld mélyszerkezete a geofizikai mérések alapján [The deep structure of the Little Hungarian Plain on the basis of geophysical measurements (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 219-240, 1960.

The Little Hungarian Plain has been investigated geophysically since 1893 by means of the pendulum, torsion balance, and gravimeter; also by magnetic measurements and, more recently, reflection, refraction, and telluric surveys. The results show two major fracture lines, trending northeast-southwest, that divide the area into three parts. In the western part the basement consists of crystalline schists and diabase, in the central part of crystalline and Mesozoic rocks, and in the eastern part of Mesozoic rocks entirely. The cover formations are Miocene and younger in the west and Eocene and younger in the east. — D. B. V.

- 185-218. Skorupa, Jan. Metody badań geofizycznych zakrytych obszarów na przykładzie północno-wschodniej Polski [Methods of geophysical investigations of covered regions in the example of northeastern Poland (with English summary)]: *Przegląd Geol.*, v. 9, no. 4, p. 206-209, 1961.

The geophysical methods used to distinguish the main structural elements of northeast Poland are described; gravity and magnetic surveys were used first and then seismic surveys. Depth to basement was determined at many points by magnetic surveying supplemented by gravity data. These values were not entirely satisfactory, however, and were checked by refraction surveys. A map is presented of the basement surface that is based on seismic and magnetic data. — J. W. C.

- 185-219. Gafarov, R. A. Stroyeniye dokembriyskogo fundamenta severa Russkoy platformy [Structure of the Precambrian basement of the north of the Russian platform]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 1, p. 59-71, 1961.

The structure of the Precambrian basement in the area comprising the east flank of the Baltic shield, the Moscow syncline, the northern part of the Volga-Ural anticline, and the Timan and Pechora synclines and their environs is elucidated on the basis of data from geophysical investigations and deep drilling. Karelian, Baikalian, and Hercynian folded systems are present. Results are compiled in maps showing the constitution and relief of the basement. — D. B. V.

- 185-220. Volodarskiy, R. F. Regional'nyye gravimetricheskiye issledovaniya vostochnykh rayonov Russkoy platformy [Regional gravimetric investigations of the eastern regions of the Russian platform]: *Moskov. Univ. Vestnik*, ser. 4, Geol. no. 6, p. 59-63, 1960.

The geology of western Bashkir A. S. S. R. and eastern Tatar A. S. S. R. is reinterpreted on the basis of new geophysical data and information from drill holes. In the area of the eastern gravity minimum (Cis-Ural downwarp) the crystalline basement lies at great depth and is not in a position to produce large anomalies in the vertical component of the magnetic field. In the western

platform areas the basement stands much higher and is lithologically inhomogeneous. Where gentle structures accompanied by gravity and magnetic anomalies occur in Paleozoic sediments of the platform, uplifts of the crystalline basement are probably present. — J. W. C.

- 185-221. Subbotin, S. I. Glubinnaya struktura territorii Ukrainskoy SSR po dannym geofizicheskikh issledovaniy [Deep structure of the territory of the Ukrainian SSR according to data of geophysical investigations (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 58-66, 1960.

On the basis of geophysical data (gravity, magnetic, and seismic) the Ukrainian S. S. R. is divided into tectonic units based on the deep structure, and the structural features of some of these units and the transition zones between them are deduced. Vertical movements of blocks have resulted from phase transformations of subcrustal material (expansion under the Ukrainian Shield; compression under the Dnieper-Donets, Pri-Black Sea, Indolo-Kuban, Pri-Carpathian, Transcarpathian, and Black Sea depressions; and complex differential expansion and compression under the Donets, Carpathian, and Crimean folded structures). The deep structures, particularly deep fractures, govern the disposition of mineral deposits and thus serve as prospecting guides. — D. B. V.

- 185-222. Sollogub, V. B. Glubinnoye stroyeniye peredovykh progibov Al'piyskoy geosynklinal'noy zony yugo-zapada SSSR po dannym geofizicheskikh issledovaniy [Deep structure of the foredeeps of the Alpine geosynclinal zone of southwestern USSR according to data of geophysical investigations (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 67-81, 1960.

The geologic structure of the Precambrian, Pri-Dobruja, North Crimean, and Azov-Kuban foredeeps of the Alpine geosyncline in the European part of the U. S. S. R. has been interpreted from geophysical surveys. The margins of the Russian platform and adjoining foredeeps have a block structure; the main joints and fractures strike northeast. The foredeeps range in age from Neogene to Jurassic and differ structurally. The Precambrian and Azov-Kuban foredeeps are of dual nature; an outer zone is characterized by platform-type folding and an inner zone by geosynclinal folding. — D. B. V.

- 185-223. Zhuravlev, V. S. Osnovnyye cherty glubinnoy tektoniki prikaspiyskoy sineklizy [Main features of the deep tectonics of the Pri-Caspian synclise]: Akad. Nauk SSSR, Geol. Inst., Trudy, no. 42, 270 p., 1960.

The third chapter of this work is devoted to the results of geophysical investigations of the Pri-Caspian synclise. Several profiles based on seismic and drilling data are presented for the Cis-Ural downwarp in the vicinity of Aktyubinsk. Extensive gravity, seismic, and magnetic surveys have been made of the Khobda, Aralsor, and South Emba gravity maximums; these results are given on maps and profiles and are discussed in detail. — J. W. C.

- 185-224. Shibato, Kihei, and Odani, Yoshitaka. Geophysical prospecting surveys for the uranium resources at Matsuiwa mine, Miyagi Prefecture [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 11, no. 6, p. 357-368, 1960.

The results of electric, magnetic, and radioactive surveys carried out at the Matsuiwa mine, Miyagi Prefecture, Japan, in August 1958 are reported. The spontaneous polarization and magnetic methods were found to be effective in outlining these hydrothermal sulfide deposits, which occur along a fault in eruptive rocks. The magnetic survey located one anomalous zone other than that produced by the known deposit. — V. S. N.

- 185-225. Thiel, Edward, and Ostenso, Ned A. The contact of the Ross Ice Shelf with the continental ice sheet, Antarctica: *Jour. Glaciology*, v. 3, no. 29, p. 823-832, 1961.

A profile of ice thickness along the 647 mile trail from Little America V to Byrd Station has been obtained from altimetric, seismic, and gravity measurements, and detailed studies made at the junction of the Ross Ice Shelf and the Marie Byrd Land plateau. The surface elevation profile clearly shows the depression characteristic of this contact. The thickness of the floating ice shelf has been determined from the elevations assuming hydrostatic equilibrium; for this purpose the accurately known density - depth relationship obtained from a deep borehole at Little America V was employed. The buried rock topography at the contact has been deduced from a seismic sounding and variations in the gravity anomaly. Movement studies over a 22 month period are presented, and the crevasse pattern of the contact is analyzed in terms of ice movement. Suggestions are given for traversing the region by vehicle. — Authors' abstract

- 185-226. Bentley, Charles R., and Ostenso, Ned A. Glacial and subglacial topography of West Antarctica: *Jour. Glaciology*, v. 3, no. 29, p. 882-911, 1961.

A summary of the techniques used and results obtained from three over-snow traverses in Marie Byrd Land and the Ellsworth Highland between January 1956 and January 1959 is presented. Seismic reflection shooting at 30 nautical mile (55.5 km) intervals was combined with gravity, magnetic, and altimetric measurements to determine the glacial and subglacial topography. It was found that a vast portion of West Antarctica has an ice-rock interface well below sea level. A major connecting channel with a maximum depth of more than 2,500 m below sea level exists between the Ross and Bellingshausen-Amundsen Seas, whereas there is no major topographic connection between the Ross and Weddell Seas. This channel divides West Antarctica into two provinces with granite and rocks of sedimentary origin to the east and south, and a volcanic region to the northwest. Present ice flow is outward from two high areas, centered over mountainous regions on either side of the channel. It is concluded that the present ice sheet has grown from the convergence of the two smaller ice sheets which formed in the mountainous areas and joined across intervening open water. (See also *Geophys. Abs.* 185-565). — Authors' abstract

GENERAL

- 185-227. Roy A[malendu], and Jain, S[udhir]. A simple integral transform and its application to some problems in geophysical interpretation: *Geophysics*, v. 26, no. 2, p. 229-241, 1961.

A simple integral transform, defined by

$$f(x) = \int_{-\infty}^{+\infty} F(x, y) dy,$$

where $F(x, y)$ represents the measured geophysical field and x and y are suitably chosen directions, has been used for formulating convenient interpretation techniques to some geophysical problems that are normally not amenable to easy quantitative interpretation. Some synthetic numerical examples are given. — Authors' abstract

- 185-228. Bullard, E. C. The automatic reduction of geophysical data: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 237-243, 1960.

The automatic recording and reduction of geophysical data is discussed, the results obtained with a proton magnetometer towed behind a ship being used as an example. Data are recorded on punched tape, the sequence of punching being controlled by a uniselector. Each number on the tape is preceded by a symbol that indicates the nature of the quantity recorded; this facilitates the elimination of punching errors and allows quantities to be punched in arbitrary sequence. The computer programme uses first and second differences to eliminate grossly erroneous readings. — Author's summary

- 185-229. Baranov, V[ladimir]. El papel de las matemáticas en el arte de la interpretación [The role of mathematics in the art of interpretation]: Rev. Geofísica, v. 19, no. 75, p. 323-330, 1960.

This is a Spanish translation of the paper published originally in French in Geophys. Prosp., v. 8, no. 2, p. 141-147, 1960 (see Geophys. Abs. 183-293). — D. B. V.

- 185-230. Heathcote, Niels H. de V., and Armitage, Angus. The First International Polar Year (1882-1883): Internat. Geophys. Year Annals, v. 1, p. 6-99, French version, p. 105-203, 1959.

This is a review of the organization, equipment, and objectives of the various countries' expeditions during the First International Polar Year: the Austrian, to Jan Mayen Land; the British-Canadian, to Great Slave Lake, Canada; the Danish, to the west coast of Greenland; the Dutch, to the mouth of the Yenisei; the Finnish, to northern Finland; the French, to Cape Horn; the German, to Baffin Land and South Georgia Island; the Norwegian, to the north coast of Norway; the Russian, to the mouth of the Lena to Novaya Zemlya; the Swedish, to Spitsbergen; and the American, to Grinnell Land and the north coast of Alaska. — D. B. V.

- 185-231. Bartels, J[ulius], and others. The Second International Polar Year: Internat. Geophys. Year Annals, v. 1, p. 205-381, 1959.

After an introduction by Bartels, the results obtained in different fields during the Second International Polar Year (1932-33) are summarized by different authors. Each part is given in both English and French. V. Laursen discusses the organization of the undertaking as a whole; C. E. P. Brooks summarizes the meteorological results, V. Laursen the geomagnetic results, J. Paton the aurora studies, W. J. G. Beynon the ionospheric observations, and E. H. Vestine and T. Nagata the ionospheric electric current systems. — D. B. V.

- 185-232. Spencer Jones, Harold. The inception and development of the International Geophysical Year: Internat. Geophys. Year Annals, v. 1, p. 383-413, French version, p. 415-446, 1959.

The development of the International Geophysical Year program is traced from the time of its informal proposal in 1950 to its ultimate organization. — D. B. V.

- 185-233. Nicolet, M[arcel] and Baker, F. W. G., eds. The Fifth meeting and the termination of the CSAGI: *Internat. Geophys. Year Annals*, v. 10, 288p., 1960.

This terminates the publications undertaken by the Comité Spécial de l'Année Géophysique Internationale at the inception of the International Geophysical Year. It includes the general reports on all the CSAGI disciplines (world days, meteorology, geomagnetism, aurora and airglow, ionosphere, solar activity, cosmic rays, latitudes and longitudes, glaciology, oceanography, rockets and satellites, seismology, gravimetry, and nuclear radiation), a list of resolutions, and the report of the termination of the CSAGI and formation of the Special Committee for Inter-Union Cooperation in Geophysics (SCG). — D. B. V.

- 185-234. Baile, Richard A. Current and future parameters in geophysics: *Geophysics*, v. 26, no. 3, p. 355-358, 1961.

The cause of the present decline in use of geophysical effort is economic; the return on investment in exploring for oil in the United States is poor. The solution lies in maintaining petroleum competitive with other sources of energy and keeping the United States competitive with other producing areas. Exploration is the key to meeting this challenge. Planning, personnel, research, and stability in exploration are discussed. — D. B. V.

- 185-235. Romberg, Frederick E. Exploration geophysics: a review: *Geol. Soc. America Bull.*, v. 72, no. 6, p. 883-932, 1961.

The art of exploration geophysics is reviewed with reference to classical and current literature. Its main features are described, the state of instrumentation and theory are discussed, and the problems it has yet to solve are examined. A 10-page bibliography is given. — D. B. V.

- 185-236. Bruckshaw, J. McG. Geophysics today: *Inst. Petroleum Rev.*, v. 14, no. 167, p. 353-355, 1960.

The capabilities of the three main geophysical methods currently in use for oil exploration—the gravitational, magnetic, and seismic—are reviewed. It is concluded that the magnetic and gravitational methods have reached the peak of their development but that there is much to be attained in the seismic method. — V. S. N.

- 185-237. Hall, T[homas] O. Is there a future need for geophysics?: *Geophysics*, v. 26, no. 2, p. 133-137, 1961.

There is a future for exploration geophysics if the industry stays modern, efficient, and competitive. Operating costs must be reduced, new tools and techniques must be developed continuously, and interpretative methods must be radically improved. Much has been accomplished in the first two of these objectives. For the third, a top-flight geophysical interpreter must be well qualified in all phases of geophysics; he must also be a competent geologist and a man with drive and imagination. A fourth objective, which vitally affects the other three, is basic research. — D. B. V.

- 185-238. Smellie, D. W. Mining exploration: *Canadian Mining Jour.*, v. 82, no. 2, p. 154-157, 1961.

The more important methods and techniques of application of geophysics, geochemistry, and geology to mining exploration during 1960 are reviewed briefly. Significant instrumental developments are also discussed. A list of 36 references is included. — V. S. N.

- 185-239. Aleksin, A. G. O printsipial'noy skheme metodiki poiskov i razvedki skopleniy nefi i gaza [Outline in principle of the method of exploration for oil and gas deposits]: *Geologiya Nefi i Gaza*, no. 4, p. 24-31, 1959.

The program of oil and gas exploration in new regions is divided into four stages. The first stage is designed to reveal the main geologic features of a region; airborne magnetic and radioactivity surveys and ground gravity surveys are combined with geomorphological studies in this phase. During the second stage the main structural elements are investigated. Gravity surveys are combined with slim-hole drilling for structural studies. The third stage provides for study of local structures for possible new oil and gas fields using structural and geophysical surveys at a scale of 1:10,000 to 1:50,000. The fourth stage consists of preparing structures for exploration drilling. Detailed seismic surveying dominates among the geophysical methods. Gravity and electrical surveys are used where the section contains rocks that are amenable to such methods. — J. W. C.

- 185-240. Mitura, Feliks. Ein Grundschema für die Methodik der Erdölprospektion [A basic scheme for methods of petroleum prospecting (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 6, p. 255-259, 1960.

A basic scheme for systematic petroleum prospecting is presented. Increasingly detailed results are obtained in four steps. A table gives the objective, methods, and main results of operations involved in each step. The first step uses gravimetric, magnetic, and geomorphic regional surveys, basic drilling, and sampling of potentially oil-bearing rocks. The second step has two stages: first, structural geologic surveys, special gravimetric and magnetic surveys, regional radioactivity and surface geochemical surveys, drilling to define structures, and sampling; and second, regional seismic investigations, special surface geochemical surveys, and precise radioactivity and resistivity surveys.

The third step also has two stages: first, special seismic investigations and precise structural geologic surveys, exploratory drilling of structures, subsurface geochemical surveys, and sampling of horizons that have oil and gas indications; and second, further drilling and sampling of oil and gas horizons, and well logging. The fourth step comprises still more drilling to delineate oil and gas horizons exactly, well logging, sampling, and test production. — D. B. V.

- 185-241. Filippov, Yu. V., Kel'ner, Y. G., and Byushgens, L. M. Karty prirody v zarubezhnykh kompleksnykh spravochnykh atlasakh (gosudarstv i rayonov) [Maps of nature in foreign complex information atlases (countries and regions)]: *Trudy Tsentral'nogo Nauchno-Issledovatel'skogo Instituta Geodezii, Aéros'emki i Kartografii* [Proceeding of the Central Scientific Research Institute of Geodesy, Airborne Survey, and Cartography], no. 125, Moscow, 147 p., 1958.

A review of 25 non-Russian atlases is presented which encompasses maps of gravity, seismicity, magnetism, volcanism, tectonics, stratigraphy, relief, oceanography, and climate. — A. J. S.

- 185-242. Hales, A. L. Research at the Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Johannesburg: Royal Soc. [London] Proc., v. 258, no. 1292, p. 1-26, 1960.

Geophysical research by the Bernard Price Institute in South Africa is reviewed. Seismological work has included studies of crustal structure, microseisms, and development of the continuous ground excitation method of prospecting. Gravity work has included pendulum and regional gravimeter surveys, and analysis of the isostatic anomalies of South Africa. Geochronological measurements have been made by the rubidium-strontium method. Paleomagnetic measurements have been made on the Pilansberg dike system, Stormberg lavas, Karroo dolerites, parts of the Bushveld Complex, and the Table Mountain series. A list of the works in which details of these studies can be found is given by subject. — D. B. V.

- 185-243. Petroleum Times. European Association of Exploration Geophysicists: Petroleum Times, v. 65, no. 1656, p. 99-101, 1961.

The proceedings of the 19th meeting of the European Association of Exploration Geophysicists in Paris, France, on December 7-9, 1960 are reviewed. Informative abstracts are given for a large number of the papers presented. — J. W. C.

- 185-244. Jaeger, J. C., and Thyer, R. F. Geophysics in Australia: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 450-461, 1960.

This is a review of recent research in geophysics of the solid earth in Australia and associated regions. More than 10,000 new gravity stations were occupied during the past year, about 70 percent by private companies; their data have been made available for use in preparation of a Bouguer anomaly map of Australia, the preliminary version of which has been compiled.

The Watheroo Magnetic Observatory's equipment and personnel were transferred in 1959 to Mundaring, about 100 miles further south. Magnetic observatories are also operated at Toolangi, Victoria; Port Moresby, Papua; Gnan-gara (near Perth), Western Australia; and also at Macquarie Island, Mawson and Wilkes stations, Antarctica. More than 700 field magnetic stations have been occupied in Australia and New Guinea since 1910; about 20 of these are reoccupied every 5 years to determine secular variation. Isogonic maps are issued every 5 years, and isomagnetic maps of all elements for the epoch 1957.5 are in press. Large areas of Australia have been surveyed by airborne magnetometer.

Two earthquakes in the Adelaide region have been studied in detail, and several seismic observatories are studying small local tremors and their geologic interpretation. A few seismic measurements of crustal thickness have been made. Work on theoretical seismology has been carried on at the University of Sydney under the direction of K. E. Bullen.

Several universities are actively studying rock magnetism in the field and in the laboratory. Heat flow measurements have been made in Tasmania, in the Snowy Mountains, and in mines and drill holes throughout the country; heat conductivity of rocks has been studied in the laboratory and the possibility of its measurement in place in water-filled boreholes has been investigated. Isotope studies and absolute age determinations by different methods have been carried on at two universities. Research is in progress at Canberra on deformation and phase transitions at high temperatures and pressures. — D. B. V.

- 185-245. Hughes, D[arrell] S. Properties of rocks under high pressure and temperature, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 308-324, 1960.

The properties of rocks under pressure that are being actively investigated at the present time—elastic constants and velocities, plastic deformation and polymorphism—are discussed in some detail. The important but somewhat neglected properties of thermal conductivity, thermal capacity, electrical conductivity, and magnetic parameters as functions of pressure and temperature are mentioned briefly; they would be of great assistance in formulating and testing hypotheses concerning the structure of the earth. A reference list of 66 items is included. — V. S. N.

GEODESY

- 185-246. Hirvonen, R. A. The reformation of geodesy: *Jour. Geophys. Research*, v. 66, no. 5, p. 1471-1478, 1961.

Three unrelated and paradoxical new ideas express a common trend toward radical reformation of geodesy. In gravimetric geodesy, where determination of the geoid has been the principal problem, the geoid is now considered to be quite unnecessary and its determination an unsolvable problem. In geometric geodesy modern computation techniques permit the use of a three-dimensional system of coordinates, thus by-passing the need for geodetic lines on the surface of a reference ellipsoid. The theory of adjustments should be based on mathematical statistics, not on the vague concept of errors that has often been considered to be a special domain of geodesy. These three ideas are discussed briefly. — D. B. V.

- 185-247. O'Keefe, John A. Discussion of paper by W. A. Heiskanen, "The latest achievements of physical geodesy": *Jour. Geophys. Research*, v. 66, no. 6, p. 1992-1993, 1961.

Heiskanen, W. A. Answer to the discussion of Dr. O'Keefe on my earlier article, "The latest achievements of physical geodesy": *ibid.*, p. 1993, 1961.

In view of objections raised by Heiskanen (see *Geophys. Abs.* 183-310) to criticism by O'Keefe (see *Geophys. Abs.* 180-183), the reasoning leading to the adoption of the value 1/299.8 for the flattening of the reference ellipsoid is stated more completely. The considerations discussed take into account fully the fact that hydrostatic equilibrium is not complete. The new numerical data mean that in estimating the contribution of the unexplored portions of the earth's gravitational field, one should assume nonhydrostatic contributions in accordance with those found from satellites, which are approximately 10 times those assumed by Heiskanen and Vening Meinesz (see *Geophys. Abs.* 175-191).

Heiskanen replies that he is convinced that after two years, when the gaps in the gravity anomaly field are filled and the results of satellite geodesy are on a firmer basis, the existing differences in opinion will disappear and the methods of physical geodesy and satellite geodesy will complete, not compete with, one another. — D. B. V.

- 185-248. Kaula, W[illiam] M. A geoid and world geodetic system based on a combination of gravimetric, astrogeodetic, and satellite data: *Jour. Geophys. Research*, v. 66, no. 6, p. 1799-1811, 1961.

A worldwide estimate of the gravity field, based on all available gravimetry and extended by using correlation with elevation in a Markov analysis, was combined with an estimate of the geoid based on astrogeodetic data covering 19 percent of the earth and with variation in satellite orbits (1957 β and 1958 β) in least squares adjustments to give the following geoid: equatorial radius—6,378,163 \pm 21 m; flattening— $1/298.24\pm 0.01$; and equatorial gravity—978,043.6 \pm 1.2 mgal (Potsdam system). Datum shifts for the Americas system are (\pm 35 m), for the Europe-Africa-Siberia-India system (\pm 38 m), and for the Japan-Korea-Manchuria system (\pm 68 m). The methods used could be improved in several respects, but it is felt that the standard deviations given for the results (\pm 10 to \pm 20 m for worldwide geoid heights) are more reliable than those given in most past studies. — D. B. V.

185-249. Arnold, Kurt. Beiträge zur gravimetrischen Geodäsie [Contributions to gravimetric geodesy]: Potsdam Geod. Inst. Veröffentl., no. 11, 30 p., 1956.

An expansion series is presented for determination of geoid undulations according to the Stokes formula that can also be used for gravimetric determination of the curvature of the plumbline of the geoid. A similar power series development given earlier by other authors is shown to be inadequate.

The gravimetric correction of astronomic leveling is treated. Defects of the so-called "circular arc condition theory" are eliminated. In determination of relative geoid undulations by the astronomic leveling method no question arises concerning the magnitude of any higher powers of an expansion series. The effect of curvature of the plumbline on astronomic-geodetic leveling can be determined separately; it is not treated here, however.

The problem of the most hypothesis-free determination of curvature of the plumbline is discussed, starting from differential quotients rather than from difference quotients. — D. B. V.

185-250. Arnold, Kurt. Numerische Beispiele zur strengen Theorie der Figur der Erde [Numerical examples of the rigorous theory of the figure of the earth]: Potsdam Geod. Inst. Veröffentl., no. 16, 66 p., 1960.

This paper is in 6 parts: (1) The formulas derived earlier for deflections of the vertical (see Geophys. Abs. 182-288) are applied to a model terrain; (2) the rigorous theory is applied to the north-south component of deflection at the Brocken massif in the Harz Mountains of Germany; (3) the corrections for deflection of the vertical for points in the vicinity of Cyprus, where gravity anomalies are intense are given; (4) the rigorous formulas for geoid undulations (see Geophys. Abs. 182-251) are applied to a model terrain; (5) the theory is applied to Mount Blanc; and (6) a general discussion is given of the foregoing results. — D. B. V.

185-251. Boaga, Giovanni. Sul calcolo delle quote ortometriche normali e convenzionali [On the calculation of normal and conventional orthometric heights]: Accad. Naz. Lincei Atti, Cl. Sci. Fis. Mat. e Nat. Rend., v. 26, no. 1, p. 9-13, 1959.

The use of observed gravity values alone (measured at the principal points along a precise leveling line) in determining orthometric heights gives results that are closer to reality than those obtained by using normal gravity values alone or observed gravity combined with theoretical gravity corrected for altitude. (See also Geophys. Abs. 185-256.) — D. B. V.

- 185-252. Ledersteger, K[arl]. Die heterogenen sphäroidischen Gleichgewichtsfiguren und das Normalsphäroid der Erde [Heterogeneous spheroidal equilibrium figures and the normal spheroid of the earth (with English summary)]: *Geofisica Pura e Appl.*, v. 44, p. 1-19, 1959.

Equilibrium figures can be characterized independently of interior density because of the condition that the absolute value of the shape parameter must be a minimum. This gives an equation between flattening and the Stokes constants ϵ and δ by which the ω^3 equilibrium figures can be selected from the ω^4 solutions of Helmert's equations for a given mass. Any inhomogeneous spheroidal equilibrium figure is determined unequivocally by the mass and shape of its free surface, or by the mass and three physical parameters; its density law is strictly individual. Out of the infinite number of equilibrium figures, linear series can be singled out either by fixing two physical parameters or by computing the figures which have a common outer level surface or the series of figures which can be formed from all the external level surfaces of a given equilibrium figure.

Although moment of inertia (C) is not a Stokes constant, the normal spheroid of the earth defined by ω , W_0 , and C can be determined without hypotheses because the moments of inertia and dynamic flattening are constant in the series (ω , K); the empirically determined dynamic flattening can be substituted for the static flattening by going back to the homogeneous initial figure of the series (ω , K). The derivation of the normal spheroid must be based on the value of gravity at the equator and the equatorial axis instead of on the unknown values of the earth's mass and geoid potential.

The three linear series (ω , W_0 ; ω , K ; and W_0 , K), which must intersect the normal spheroid, and the boundary surface of the equilibrium figures in Cartesian coordinates are also discussed. — D. B. V.

- 185-253. de Graaff-Hunter, J[ames]. The shape of the earth's surface expressed in terms of gravity at ground level: *Bull. Géod.*, no. 56, p. 191-200, 1960.

In the model earth with smoothed topography (see *Geophys. Abs.* 178-202), slopes hardly exceed 0.01. The data of gravity and potential at the surface of the actual earth can easily be related to the corresponding data for the model earth; if the problem of the shape of the model earth is then solved, the shape of the actual earth follows without difficulty. A solution based on Green's theorem is given.

This method involves assumptions of crustal density in a layer between the actual earth and model earth of thickness h - H ; in isostatic methods the assumptions concern thickness h . — D. B. V.

- 185-254. Schmidt-Falkenberg, Heinz. Die geodätischen Grundlagen unserer Kartenwerke von der Erde [The geodetic bases of our mapping of the earth]: *Forschungen u. Fortschritte*, v. 34, no. 1, p. 10-13, 1960.

This review of the geodetic basis of cartography discusses such questions as references surfaces, the mean earth ellipsoid, the different altitude systems and their mutual relations, working heights, and the German main altitude network. — D. B. V.

- 185-255. Fischer, Irene. A map of geoidal contours in North America: *Bull. Géod.*, no. 57, p. 321-324, 1960.

A map of geoidal contours of North America, constructed by Hayford's method, is presented. Comparison with Hayford's map of 50 years ago shows not only that large blank areas have been filled in, but also that there are pronounced differences in elevation in the Western United States, where Hayford's values averaged 30 m higher and were never negative. A comparison with the 1951 Canadian map shows agreement in general features, with some discrepancies of smaller degree.

A noteworthy feature of the map is a geoidal depression north of the Great Lakes, with an apparent center in the southwestern part of Hudson Bay. This may be related to the last glaciation (see *Geophys. Abs.* 176-161); if so, the amount of expected postglacial uplift may be in some proportion to this depression. — D. B. V.

- 185-256. Boaga, Giovanni. Sulle livellazioni dinamiche [On dynamic leveling]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis. Mat. e Nat. Rend.*, v. 25, no. 6, p. 395-400, 1958.

Comparison of results obtained using observed and normal gravity values shows that in determining dynamic heights along lines of precise leveling, particularly in zones of large gravity anomalies, it is not sufficient to use normal gravity values. Measurements must be made along the altimetric route at all principal points using the formula for dynamic height given in an earlier paper (see *Geophys. Abs.* 178-210). — D. B. V.

- 185-257. Ramsayer, Karl. Report about gravity reduction of the levelling network in Baden-Württemberg (summary): *Bull. Géod.*, no. 52, p. 76-79, 1959.

In order to compare the different altitude systems in a large leveling network, the following heights were calculated for the junction points of the Baden-Württemberg network in Germany: geopotential numbers, dynamic heights, Helmert heights, heights with minimum gravity reduction, and heights without gravity reduction. The smallest corrections were obtained by using measured heights without any gravity reduction and adjusting them; this method is therefore suitable for ordinary use, but as it does not take closure error into account, it cannot be used for highly precise work.

A worldwide system of heights suitable for both scientific and practical purposes is obtained by using Helmert heights as follows: the leveling network is adjusted with the Helmert reduction without further gravity reductions; the lines of equal differences between Helmert heights and leveling heights are plotted on a map; if later a line of second or lower order is measured, the difference at the beginning and end of the line is read from the map to give an approximate value of the Helmert reduction of the line.

In order to determine whether normal gravity could be used instead of true gravity, normal dynamic and normal orthometric heights were also calculated. Use of normal gravity reduction reduces the mean square error from 0.99 mm per $\sqrt{\text{km}}$ to 0.74 mm per $\sqrt{\text{km}}$; use of true gravity reduces it still further to 0.64 mm per $\sqrt{\text{km}}$. — D. B. V.

- 185-258. Baeschlin, C. F. Rapport spécial sur le nivellement et la pesantur [Special report on leveling and gravity]: *Bull. Géod.*, no. 57, p. 247-298, 1960.

According to a decision made at the International Association of Geodesy at its 1954 meeting in Rome, all international comparisons and adjustments of geodetic networks should be made only by the differences in geopotential numbers. The gravimetric aspects of precise leveling are discussed in the light of this resolution. The eleven sections of the report are devoted to geopotential heights, orthometric altitudes, transformation of raw leveling altitudes into geopotential heights, orthometric correction of raw leveling altitudes, formation of geopotential heights, theory of errors in gravity reduction of levelings, layout of gravimetric stations, application of the theory of errors to some examples, methods of calculating orthometric altitudes, ordinary altitudes, and the use of spheroidal altitudes and isoanomaly maps. — D. B. V.

- 185-259. Kääriäinen, Erkki. Adjustment of the Northern Bloc in U. E. L. N. and accuracy of the geopotential differences in it: *Bull. Géod.*, no. 57, p. 299-310, 1960.

The results are reported of computation of the mean errors for existing geopotential differences for the Northern Bloc (Norway, Sweden, and Finland) of the United European Leveling Networks (U. E. L. N.), made in connection with the resolution to use only geopotential numbers in international comparisons and adjustments (see *Geophys. Abs.* 185-258). — D. B. V.

GEOTECTONICS

- 185-260. Ringwood, A. E. Changes in solar luminosity and some possible terrestrial consequences: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 295-296, 1961.

The geologic consequences of an increase of the sun's luminosity by a factor of 1.6 during the past 5 billion years, as calculated recently by astronomers, are pointed out. Other factors being equal, the average surface temperature of the earth must have increased 30°C-40°C over that period. This implies that from the time of the earth's formation some 4.5 billion years ago until about 3 billion years ago most of the water on the earth was frozen. During such an intense ice age normal surface geological processes would not be operative, and crustal dynamics would be radically different. The formation of sediment-filled geosynclines would be prevented, and thus the processes of metamorphism, granitization, and the formation of silicic magmas associated with geosynclinal folding would not occur.

Most ancient dated rocks are of granitic origin; if the formation of such rocks was prevented, a possible explanation for the marked hiatus in age determinations between 3 and 4.5 billion years is apparent. In that period the continents may have consisted largely of mafic and intermediate volcanics formed by fractional melting of the upper mantle. The Conrad discontinuity may represent the original surface of the earth about 3 billion years ago, before the normal geologic cycle began to operate. — D. B. V.

- 185-261. Eardley, Armand J. The cause of mountain building—an enigma, in *Science in progress* 11th ser.: New Haven, Yale University Press, p. 1-37, 1960.

The foundations of the earth's crust are discussed and illustrated by a general survey of the problems of the Rocky Mountains and Appalachian Mountains, the constitution of the North American continent, the nature of the ocean basins as deduced from modern exploratory methods, and finally by a comparison of ocean basins and continents. Hypotheses to explain the mechanisms of mountain building are classified, and the concepts of the principal

categories presented briefly. The following hypotheses are included: older contraction; Wegener's continental drift; radioactivity and melting of the subcrust including Joly's global subcrustal melting, Vening Meinesz' tectogene, and Rich's blister hypotheses; Hess and Benioff's mantle fault; Bucher's gravity sliding; Wilson's (detailed by Eardley) asymmetric convection; Hess' serpentinization; and Ewing and others' tension hypothesis. — V. S. N.

- 185-262. Beck, A[lan] E. Energy requirements of an expanding earth: Jour. Geophys. Research, v. 66, no. 5, p. 1485-1490, 1961.

To estimate the energy required for, and hence the physical possibility of, an expanding earth, the gravitational potential energy of the present earth and of various primitive earth models are compared. If the primitive density distribution is given by $\rho = \rho_0(1 - kr^n)$, then with plausible values of ρ_0 , k , and n expansions of the radius of about 100 km, with a net loss of gravitational potential energy, cannot be ruled out. Earth models with moments of inertia higher or lower than that of the present earth can be selected from the range of plausible smaller primitive models available for each value of n . Expansions of the radius of about 1,000 km can be entertained only if highly improbable density distributions are assumed. The conclusions are not substantially altered even when additional sources of energy are taken into account. [See also Geophys. Abs. 181-239.] — Author's abstract

- 185-263. Reitan, Paul H. The earth's volume change and its significance for orogenesis: Jour. Geology, v. 68, no. 6, p. 678-680, 1960.

Recent studies on the thermal history of the earth (Jacobs, 1956; MacDonald, 1959) [see Geophys. Abs. 173-218, 179-236] allow the net volume change of the earth due to temperature changes during the last 10^9 yr to be calculated. The circumference changes for four models vary from -13 km (contraction) to approximately +31 km (expansion). From this it appears that orogeny cannot be explained as the result of contraction due to heat loss. — Author's abstract

Cox, Allan [V.], and Doell, Richard R. Paleomagnetic evidence relevant to a change in the earth's radius. See Geophys. Abs. 185-449.

- 185-264. Aslanyan, A. T. Dinamicheskaya problema geotektoniki [The dynamic problem of geotectonics (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 5-16, 1960.

If the contraction hypothesis is liberated from five false assumptions, it appears to be the only justifiable theory of crustal evolution from the point of view of energetics. The questionable assumptions concern the adoption of the relaxation principle; crustal stability and its limits; the elastic limit; the interpretation of negative gravity anomalies over folded ranges; and the spasmodic nature of folding, orogenic phases, and contraction. The assumptions are examined mathematically and the true picture elucidated. — D. B. V.

- 185-265. Hailes, T. Binnert. Perspectives in the solar system: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 12, p. 345-362, 1960.

The stations of the planets on a radius of the solar system appear to be perspectiveally related to the absolute dates of terrestrial diastrophisms and probably also to the spacing of the discontinuities in the earth's interior and atmosphere. This points to cosmic forces as the cause of terrestrial orogenies

and discontinuities; it also follows that the planets were born in the order of their increasing distances from the sun and are much younger than is generally accepted. Mass redistributions accompanying their births disturbed the existing gravity regime of the solar system and caused diastrophisms and development of discontinuities on the pre-existing planets. This hypothesis accounts for six orogenic sequences on earth. Given the stations of the planets and the absolute dates of three major orogenic events, other diastrophisms can be found by interpolation and extrapolation; similarly, depths of three first-order discontinuities would determine the spacing of other transition zones. — V. S. N.

- 185-266. Harrison, E. R. Origin of the Pacific Basin: a meteorite impact hypothesis: *Nature*, v. 188, no. 4756, p. 1064-1067, 1960.

To explain the major surface characteristics of the Pacific Basin, which is surrounded by a variety of features parallel to its coastlines, it is proposed that the basin was the seat of an immense explosion in the primitive earth and that this explosion might have been due to collision with a planetesimal or satellite about 100 km in radius. A large crater several hundred kilometers in radius and some hundreds of kilometers deep was excavated. The great masses of material that were swept back and dropped at the crater rim formed the discontinuities of crustal structure and composition that survive to the present day and are responsible for the peripheral features of the basin. Following the recovery of hydrostatic equilibrium, there remained a shallow permanent depression (because of the absence of surface layers) which is the present Pacific Basin. — D. B. V.

- 185-267. Subbotin, S. I. O prichinakh i mekhanizme obrazovaniya platformennykh i geosinklinal'nykh progibov zemnoy kory [On the causes and mechanism of formation of platform and geosynclinal depressions of the earth's crust (with English summary)]: *Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18*, p. 39-49, 1960.

The formation of geotectonic units and structures that determine the distribution of mineral deposits is related to polymorphic changes at depth accompanied by volume changes. Crustal depressions are caused by decreases in volume in the asthenosphere at depths up to 300 km. Areas of compression and expansion are determined on the basis of regional gravity anomalies, seismological data, and other geophysical and geological data. The phase transformations result from changes in geodynamic stresses in the mantle. These polymorphic changes occur in a horizontal layer and are accompanied by absorption or release of energy; the energy transfer brings thermodynamic conditions in the underlying and overlying layers to a critical level so that polymorphic conversion takes place in a sort of chain reaction successively involving new layers.

The dynamics of formation of platform depressions and geosynclines are described in some detail. — D. B. V.

- 185-268. Fedynskiy, V. V. Geofizicheskiye dannyye o nekotorykh chertakh stroyeniya i razvitiya zemnoy kory [Geophysical data on certain features of the structure and development of the earth's crust (with English summary)]: *Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2*, p. 5-13, 1960.

Present knowledge of the thickness, nature, and development of the earth's crust as revealed by geophysical investigations is summarized. The weight of evidence favors the hypothesis that the principal cause of oscillatory movements, and probably also of horizontal movements, is phase transitions in the subcrustal material. The structure and the geologic history of large crustal blocks are determined mainly by endogenous forces. — D. B. V.

- 185-269. McBirney, A[lexander] R., and Best, Myron G. Experimental deformation of viscous layers in oblique stress fields: *Geol. Soc. America Bull.*, v. 72, no. 3, p. 495-498, 1961.

Alternating layers of soft viscous wax and asphalt were squeezed in various orientations within a constant-strain squeeze box. Compression produced folds and small wrinkles whose axial orientation is determined solely by the intersection of the plane normal to the direction of maximum shortening with the layer surface. Formation of folds in viscous materials appears to be a function of the strain rate. — Authors' abstract

- 185-270. Belousov, V. V. Experimental geology: *Sci. American*, v. 204, no. 2, p. 96-104, 1961.

An account is given of laboratory work in the U. S. S. R. on the use of scale models to visualize tectonic processes. Most of the material discussed in this paper is included in the more technical version by Belousov published in *Geol. Soc. America Bull.*, v. 71, no. 8, p. 1255-1270, 1960 (see *Geophys. Abs.* 183-346). — V. S. N.

- 185-271. Ma, Ting Ying H. Continental drift and polar wandering: Research on past climate and continental drift, v. 15, 24 p., 1960.

This is a further development of Ma's thesis that continental drift and polar wandering have been caused by the repeated sudden total displacement of the solid earth shell. This displacement may be traced from coral reef data and has resulted in producing the major tectogenic structures and sedimentary anomalies of the ocean floor. (See also *Geophys. Abs.* 174-170, -171.) — V. S. N.

- 185-272. Ma, Ting Ying [H.]. My genetic view of major structures on the ocean floor: *Oceanographia Sinica*, v. 6, no. 1, 18 p., 1960.

The major tectogenic structures and their patterns in the ocean basins as well as the sedimentary anomalies on the ocean floor came from the repeated sudden total displacement of the solid earth shell over the liquid core and the accompanying drift of continental crustal masses. Studies of tectogenic structures and alteration of sedimentary facies on the ocean bottom make it possible to determine the course of displacements of the earth shell and of drift of the continents during the Cenozoic. — V. S. N.

- 185-273. Raven, Theodore. Alpine folding as related to continental drift: *Eclogae Geol. Helvetiae*, v. 53, no. 1, p. 161-168, 1960.

Modern ideas of Alpine paleogeography are reconciled with the hypothesis of continental drift. The fact that the main orogenesis was not contemporaneous with or immediately subsequent to the collision at the end of the Jurassic of northeastward-drifting Africa and eastward-drifting Eurasia is explained if the acme of compression occurred when the convection currents had optimal speed and power but the acme of drift was when the slowly accelerating cur-

rents were not yet bothered by sial in their descending branches (before the Tethys was bridged by sial in its floor). In Early Cretaceous the mechanism changed from the type conceived by Holmes to that of Vening Meinesz—the convection system disengaged from the continental crust when sial entering into the root acted as a brake.

Holmes' idea of a wide Tethys separating Gondwanaland from Laurasia is accepted; the paleogeographic evidence allows this essential departure from Wegener's concept of Pangaea. With this arrangement the Carboniferous coal fields of the northern hemisphere fall in the tropical belt, and the Permocar-boniferous glacial deposits that are too extensive to have been due to mountain glaciers are conveniently grouped around the South Pole. Two land bridges permitted land plants and animals to cross the Tethys, the eastern one represented by the continuous sialic swell still connecting southeast Asia to Australia, and the western one comprising the sialic crust under Italy and part of the ocean floor between the Azores and Portugal and Morocco. — D. B. V.

- 185-274. Evison, F. F. On the growth of continents by plastic flow under gravity: Royal Astron. Soc. Geophys. Jour., v. 3, no. 2, p. 155-190, 1960.

A coherent explanation of many major geologic phenomena follows from the hypothesis that the strength of basement rocks at shallow levels is very small for long-continued stresses, and that gradual plastic flow occurs widely in a superficial layer of the crust. A likely mechanism of flow in a layer 2-3 km thick is that of solution and recrystallization. It is shown that the continental masses are approximately in equilibrium for a yield point of the order of 10^6 d per cm^2 ; and increase in their average height by volcanic or orogenic activity causes the continents to grow in area and thus to encroach on neighboring oceans. The growth pattern is generally asymmetrical and changes with time; recent rates of radial expansion have ranged up to the order of 0.1 cm per yr.

The configuration of the slip-line field in a plastic sheet suggests a mechanism of geologic faulting by shear fracture induced by plastic flow. Rift valleys and tilted blocks are thus seen as essentially shallow phenomena. Thrust sheets and insular aprons are attributed to extrusion at the base of plastically subsiding mountains and seamounts. The fundamental postulate of stress tectonics, that the crust is acted upon by horizontal forces originating in the mantle, becomes largely redundant. Disturbances projected into the substratum as a result of superficial flow are linked with orogenic, volcanic, and seismic activity in a complex of cause and effect. It is suggested that mid-oceanic elevations develop by deformation of the substratum due to progressive loading at the adjacent margins as the continents expand. — D. B. V.

- 185-275. Bondarchuk, V. H. Pro heolohichni rukhy i yikh pokhodzhennya [On geologic movements and their origin (with Russian summary)]: Akad. Nauk Ukrain. RSR Heol. Zhur., v. 20, no. 1, p. 3-16, 1960.

Geologic movements are geocosmic (simple mechanical displacements), tectonic (more complex mechanical and physical movements with related sub-tectonic plastic movements), gravitational (complicated mechanical displacements and physicochemical processes), and geochemical (very complex movements of matter affecting the entire thickness of the outer shell of the earth). Their character and direction vary with the composition and physical state of the mineral mass. The outer mobile part of the earth, or tectonosphere, consists of the bathytectonic (deep), hypotectonics (intermediate, and epitectonic (shallow) zones. In the bathytectonic zone polar flattening and equatorial expansion occur as a result of the earth's rotation; these are related to deep migration

and differentiation of matter. In the crust, or hypotectonic zone, the chief motions are subsidence or uplift; magma generation is one of the forms of tectonic movement connected with geosynclinal subsidence. The epitectonic region is the scene of gravitational movements which bring about a complete qualitative reorganization of the material of weathering, erosion, and sedimentation. — D. B. V.

- 185-276. Peyve, A. V. Tektonika i magmatizm [Tectonics and magmatism]: Akad. Nauk SSSR Izv. Ser. Geol., no. 3, p. 36-54, 1961.

Recognition of the block structure of the earth's crust and of the importance of horizontal movements is fundamental in modern tectonic concepts. The problem of crustal structure and movements and their relation to magmatism is examined in this review, written to honor the memory of F. Yu. Levinson-Lessing. — D. B. V.

- 185-277. Charlesworth, H. A. K. Some observations on the origin of the earth's crust: Edmonton Geol. Soc. Quart., v. 4, no. 11, p. 1-7, 1960.

The oceanic crust or sima should be considered as an extension of the upper mantle since it is chemically indistinguishable from it; its thickness is controlled by the depth at which the basalt-eclogite transition occurs, and this depends on the temperature variation within the upper mantle. As basalt is added to the sima by extrusion on the ocean floor, isostatic depression occurs, leading to a temporary lowering of the M-discontinuity; as basalt changes to eclogite and equilibrium is restored, the thickness of the sima is kept approximately constant. Epeirogenic movements of both oceanic and continental crustal areas may be caused by temperature changes in the neighborhood of the M-discontinuity (possibly associated with convection currents in the mantle).

Recent studies by Officer et al (see Geophys. Abs. 180-243) suggest that continents are made up of segments that are the end-product of periods of sedimentation and volcanic and orogenic activity. The raw material that contributes to continental growth is andesite produced by differentiation or some similar process within the crystalline mantle. The cycle of activity in continental accretion is discussed and illustrated. Eventually continental sial will probably cover the entire earth's surface, continental drift will no longer be possible, and the present type of mountain building will come to an end. — V. S. N.

- 185-278. Sheynmann, Yu. M. Velikiye obnoveniya v tektonicheskoy istorii Zemli [Major rejuvenations in the tectonic history of the earth (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 104-113, 1960.

Stille's distinction of three major periods of structural development separated by epochs of rejuvenation is examined in the light of recent Precambrian age determinations. Present knowledge confirms the fact of structural rejuvenation. This regeneration is regional and does not involve the whole earth during a given period. The process is not a simple rejuvenation of existing structures, but involves the formation of new patterns. In the destruction of preexisting platforms and their marginal belts, some parts develop into new geosynclinal systems and others form the cratons of the next epoch; the concept of an old nucleus gradually expanding by addition of younger structures is incorrect.

Two or three periods of regeneration can be distinguished in the basements of Africa and India and probably also of the Canadian and Russian platforms. The oldest periods of regeneration evidently were not contemporaneous. The process of destruction and regeneration began at least 3,000 million years ago, when platforms and geosynclines were created. — D. B. V.

- 185-279. Lindström, Maurits. Methods of differentiating tectonic regimes: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 347-352, 1960.

Large amounts of data are required to distinguish chance deformation of the crust from regularly occurring trends of tectonic regimes. Furthermore, to differentiate tectonic regimes one must be able to distinguish unimodal from polymodal or discontinuous variation in the deformation features. This cannot be done solely from maps, but requires synoptic diagrams that disregard the local context of data. The significance of small-scale data which can be collected in vast amounts (such as lineations, interrelations of small folds, or β -intersections of cleavage planes) is discussed in the light of experience in the northern Caledonides of Sweden. — D. B. V.

- 185-280. Wilson, J. Tuzo. Geophysics and continental growth, in Science in progress, 11th ser.: New Haven, Yale University Press, p. 61-91, 1960.

This is virtually the same as the paper published in Am. Scientist, v. 47, no. 1, p. 1-24, 1959 (see Geophys. Abs. 176-162). — V. S. N.

- 185-281. Pushcharovskiy, Yu. M. Osobennosti tektonicheskogo stroyeniya i razvitiy krayevykh progibov [Features of the tectonic structure and development of foredeeps (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 73-79, 1960.

The term longitudinal foredeep, or simply foredeep, should be applied only to deep linear synclines located at the junction of platform and folded areas, which originate and develop during the period of completion and uplift of geosynclines. There are essential differences between foredeeps bordering old (Precambrian) and young platforms. Those of the former group consist of an outer zone in which dislocations are of platform type and an inner zone of folding, whereas those of the latter group, which are exceptionally disproportional, have no such division. The simpler structural features of the second group are explained by the comparative mobility of young platforms; as they are more yielding, conditions are favorable for the smoother discharge of tectonic strains. — D. B. V.

- 185-282. Stovas, M. V. Deyaki zakonornosti v hoehrafichnomy rozpodili platform i skladchastosti [Some regularities of the geographic distribution of platforms and folding]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 4, p. 54-61, 1960.

The distribution of platform and geosynclinal areas is explained in terms of deforming forces called into play by variations in the earth's rotational velocity (see Geophys. Abs. 178-52, -206, -207; 179-192; 180-52). — D. B. V.

- 185-283. Glangeaud, Louis, Caire, André, and Grandjacquet, Claude. L'orogénèse ponto-plio-quatenaire de l'arc calabrosicilien et ses caractères géodynamiques [The Ponto-Plio-Quaternary orogenesis of the Calabro-Sicilian arc and its geodynamic features]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 1, p. 145-147, 1961.

Data from gravimetric and seismologic investigations are used in conjunction with structural and geomorphic evidence to explain the formation of the Calabro-Sicilian arc. Two phases of folding are recognized, one earlier and the other later than deposition of the Miocene polychrome series. — D. B. V.

- 185-284. Sugimura, Arata. Zonal arrangement of some geophysical and petrological features in Japan and its environs: Tokyo Univ. Fac. Sci. Jour., sec. 2, v. 12, pt. 2, p. 133-153, 1960.

The topography, gravity, earthquake seismology, and volcanic petrology of Japan and its environs exhibit a regular zonal arrangement along two island arcs—one from Kamchatka through the Kuriles, northeast Japan, and the Si-tito (Shichito) to the Mariana Islands; the other from Kyushu through the Ryukyu Islands to Taiwan. Each zone is characterized by a foredeep; a characteristic distribution of gravity anomalies, seismic velocities, younger volcanoes and hot springs; and a seismic plane which slopes toward the continent. The chemical compositions of the basaltic rocks of the Japanese volcanoes show a near constant value for each volcano as well as a geographic distribution of the values that seems to be related to the above zones and particularly to the depths of earthquake focuses. The deeper the earthquake focus, the more alkalic are the rocks erupted above it; the shallower, the more silicic. A grouping of volcanoes of Japan into two volcanic belts based on zonal relationships is proposed to replace the currently used volcanic zones. — V. S. N.

- 185-285. Azhgirey, G. D. Geologicheskkiye usloviya formirovaniya, kinematika i dinamika obrazovaniya skladok geosinklinal'nogo tipa [Geologic conditions of forming, kinematics, and dynamics of evolution of folds of geosynclinal type (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 59-64, 1960.

In geosynclines folding is due mainly to upward plastic flow of material under tangential compression. Study of flow cleavage provides the most valuable data on the kinematic conditions of deformation. The festoon, arcuate plan characteristic of almost all folded belts can be explained only by tangential deforming forces oriented transversely with respect to the trend of the linear folds. Horizontal shifting along the strike, also caused ultimately by tangential forces, sets folded complexes en echelon with respect to the strike of the fold belt as a whole.

The main systems of anticlines of geosynclinal type are formed above older deep faults; this position is determined by an increase in heat flow along these faults at times of more intense orogeny. The concept that the main stages of folding and orogenic uplift are not contemporaneous is contradictory to the established kinematic conditions of folding. — D. B. V.

- 185-286. Azhgirey, G. D. Dva geneticheskikh tipa geosinklinal'noy skladchatosti [Two genetic types of geosynclinal folding]: Moskov. Univ. Vestnik, Ser. 4, Geol. no. 6, p. 13-26, 1960.

Folding in the central tectonic zones of geosynclines during the early stages of the tectono-magmatic cycle is greatly different from that during the late stages. The early folding is syndimentary and develops under conditions of general subsidence of the crust. The late folding is orogenic and is expressed by a general uplift of the crust in the mobile belts. Examples of these two types of folding in the Greater Caucasus are discussed. — J. W. C.

- 185-287. Scheidegger, A[drian] E[ugen]. Faults and earthquakes: Canadian Oil and Gas Industries, v. 14, no. 4, p. 33-42, 1961.

An evaluation of the stresses within the earth and the effect of these stresses on deformation of the material composing the earth should make it possible ultimately to tell what kind of structures will be found in various places near the surface. Such information would be of great importance in oil exploration. Several theories—contraction, polar wandering, convection, and continental drift—for the physical processes or orogenies that may have caused the deformations of the earth's crust are reviewed briefly. Most of the theories lead to a very uniform stress state in the crust, and this stress state should be responsible for all of the deformations. The effects of the stresses may be studied by geological field work; study of well fracturing data and seismic observations are means of determining the actual stresses. Fault plane solutions are discussed in some detail as a key to the large-scale tectonic picture of an area. Examples are cited from the Caucasus and eastern Asia. — V. S. N.

- 185-288. Oulianoff, N[icolas]. Cassures, eau et déplacements des masses rocheuses par les efforts tectoniques [Fractures, water, and displacements of rock masses by tectonic forces]: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 277-279, 1960.

Folds are actually the sum total of innumerable very small fractures. Fossil waters set in motion by tectonic forces lubricate fractures of all dimensions and facilitate the deformation of rock masses by those forces. — D. B. V.

- 185-289. Peyve, A. V. Razlomy i ikh rol' v stroyenii i razvitií zemnoy kory [Fractures and their role in the structure and development of the earth's crust (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 65-72, 1960.

The English version of this paper has been published in the Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 280-286, 1960 (see Geophys. Abs. 184-352). — D. B. V.

Tazieff, Haroun. Concerning the tectonic significance of large landslips provoked by the great Chilean earthquake of May 1960. See Geophys. Abs. 185-131.

- 185-290. Ehara, Shingo. The Kaikoura diastrophism and the Fossa Magna disturbance: Jour. Geography [Tokyo], v. 69, no. 5, p. 200-208, 1960.

The middle Tertiary orogenic movements in New Zealand (Kaikoura diastrophism) and in Japan (Fossa Magna disturbance) are believed to have produced the deep earthquake zones that are associated with the westward dipping fault zones intersecting the Tonga-Kermadec Trench off New Zealand and the Shichito Trench off Japan. These fault planes are believed to represent the boundary between the underthrusting forces of the Pacific basin and the overthrusting forces of the Asiatic continent. — V. S. N.

- 185-291. Khain, V. Ye. Osnovnyye tipy tektonicheskikh struktur, osobennosti i prichiny ikh razvitiya [Main types of tectonic structures, their features and causes of development (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 89-103, 1960.

This is the Russian version of a paper published in English in *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 215-226, 1960 (see *Geophys. Abs.* 183-319). — D. B. V.

Rodiger, Kurt. Analysis of salt dome uplifts with the aid of electric logging, as shown at the Bramstedt and Etzel salt domes. See *Geophys. Abs.* 185-211.

185-292. Sim, Victor W. Maximum post-glacial marine submergence in northern Melville Peninsula: *Arctic*, v. 13, no. 3, p. 178-193, 1960.

The crustal depression produced by the weight of the ice sheet over the Melville Peninsula on the east coast of the Northwest Territories, Canada, is estimated to have been at least 1,100 feet. The amount of uplift in the peninsula to date has been approximately 450 feet and, assuming that the process of depression is completely reversible, the crust should rise another 650 feet before equilibrium will have been reestablished. At present there is no method of measuring the amount of early recovery that took place as the ice started to melt and before the margin retreated sufficiently to allow the sea to inundate the land to form strandlines. Four criteria for determining the post-glacial marine submergence in this area are discussed in detail: (1) the highest altitude at which marine shells occur; (2) the highest altitude at which strandlines are preserved; (3) the lowest altitude at which undisturbed ground moraines can be recognized; and (4) the lowest altitude at which perched boulders are found. — V. S. N.

185-293. Kropotkin, P. N. Neotektonika i geofizicheskiye dannyye o tolshchine i deformatsiyakh zemnoy kory [Neotectonics and geophysical data on the thickness and deformations of the earth's crust (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 18, p. 80-88, 1960.

Neotectonic maps showing total vertical displacements during Neogene and Quaternary time have been compiled for the U.S.S.R. as a whole, for the world, for individual continents, and for certain areas within the U.S.S.R. These have been compared with the gravimetric maps (Bouguer) compiled by Kropotkin and Lyustik (1956-58) which also give seismic data on crustal thickness.

Horizontal movements of individual crustal blocks evidently play a predominant role in recent deformation. Tension results in the formation of large troughs, the expansion of ocean basins, and thinning of the crust; compression results in thickening of the crust and formation of folds and overthrusts. The most recent major structural units of the crust are oceanic platforms, geosynclines, and continental platforms. Within the latter, stable and mobile areas may be distinguished according to the degree of recent deformation. — D. B. V.

Shepard, Francis P. Rise of sea level along northwest Gulf of Mexico. See *Geophys. Abs.* 185-35.

Koldewijn, B. W. Sediments of the Paria-Trinidad shelf. See *Geophys. Abs.* 185-37.

185-294. Popov, V. V., and Chernyavkina, M. K. Nekotoryye rezul'taty nablyudeniy nad deformatsiyami zemnoy poverkhnosti na geofizicheskoy stantsii "Yalta." [Some results of observations of deformations of the earth's surface at the geophysical station "Yalta"]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 1005-1012, 1960.

An attempt to develop and employ an efficient method for interpreting and evaluating the observation data on tilting and slow deformation of the crust at the geophysical station "Yalta" is reported. Diurnal periodic displacements having harmonics of the first and second orders are definitely established. The amplitude maximums of both harmonics occur during summer months, having maximum values of 10^{-7} and 2×10^{-8} , respectively. The forms of vector diagrams of variations in diurnal deformations are similar, but their amplitudes and the directions of their major axes change from month to month turning from NW to SE in winter and in the opposite direction during the summer. An annual periodicity in amplitude and direction of tilt and displacement is qualitatively established, and approximate amplitudes of the components are given. — A. J. S.

- 185-295. Sakaguchi, Yutaka. The crustal movement of Hokkaido in the latest geologic age [in Japanese with English abstract]: *Geog. Rev. Japan*, v. 32, no. 8, p. 401-431, 1959.

Recent crustal movements in Hokkaido as illustrated by two marine terraces in the Haboro district in northwestern Hokkaido are described. The relation of the terrace altitudes to tectonic movements in Hokkaido and the chronology of the terrace-surface-forming periods are discussed. It is shown that the coast lines with large vertical displacements of former shore lines are parallel to a series of major structural lines and to the Ezo Arc; this indicates that the activity of the Kuril Arc has continued during the latest geologic time. — V. S. N.

GLACIERS

- 185-296. Allen, C[laurence] R., Kamb, W. B[arclay], Meier, M[ark] F., and Sharp, R[obert] P. Structure of the lower Blue Glacier, Washington: *Jour. Geology*, v. 68, no. 6, p. 601-625, 1960.

The physical behavior of glacier ice is of particular interest as an indication of how other rocks may react under conditions of higher temperature, confining pressure, and stress. In this paper results are discussed of a study of some structures in the Blue Glacier—the foliation pattern, an unusual longitudinal septum, ogives, crevasses, and related ice fabric. A 300-m icefall separating the major accumulation basins from the ice tongue plays a dominant role in the formation of the principal foliated structures. Three types of ice are involved, coarse-bubbly ice, coarse-clear ice, and fine ice. Most or all of the latter represents partly recrystallized insets or infolds of firn. — V. S. N.

- 185-297. Sharp, Robert P., Epstein, Samuel, and Vidziunas, Irene. Oxygen-isotope ratios in the Blue Glacier, Olympic Mountains, Washington, U.S.A.: *Jour. Geophys. Research*, v. 65, no. 12, p. 4043-4059, 1960.

The mean permil deviation from a standard (average ocean water) in the O^{18}/O^{16} ratio of 291 specimens of ice, firn, snow, and rain from the Blue Glacier is -12.4; extremes are -8.6 and -19.2. This is consistent with the moist temperate climatological environment. The O^{18}/O^{16} ratio of snow decreases with declining temperature of precipitation, and it also decreases with increasing altitude at a rate of 0.5 per 100 m. The ratios for coarse-clear ice are generally lower and for fine ice generally higher than for coarse-bubbly ice. This indicates that the fine ice represents masses of firn and snow recently incorporated into the glacier by filling of crevasses or by infolding in areas of severe deformation. Coarse-clear ice masses may re-

present fragments of coarse-bubbly ice within a breccia formed in the ice-fall; because of unfavorable orientation, these fragments could have undergone exceptional recrystallization with reduction in air bubbles and, possibly, a relative decrease in O^{18} .

A longitudinal septum in the lower Blue Glacier is characterized by higher than normal ratios, consistent with an origin involving incorporation of much surficial snow and firn near the base of the icefall. Samples from longitudinal profiles on the ice tongue suggest that ice close to the snout comes from high parts of the accumulation area. Analyses from the light and dark bands of O -gives are compatible with the concept that the dark bands represent greatly modified insets of firn-ice breccia filling icefall crevasses.

The range in ratios is much greater in the accumulation area than in the ice tongue; this is attributed to homogenization, mostly during the conversion of glacier ice. This concept is supported by comparative analyses of snow when new and months later after alteration. Refreezing of rain and meltwater percolating into underlying cold snow is an important mechanism, as shown by analyses of ice layers and lenses in the firn formed in this manner. — D. B. V.

185-298. Paterson, W. S. B. Movement of the Sefstrøms Gletscher, north-east Greenland: *Jour. Glaciology*, v. 3, no. 29, p. 845-849, 1961.

In the summer of 1958 weekly observations were made of the horizontal and vertical components of surface movement of the Sefstrøms Gletscher, north-east Greenland. The glacier is of the subpolar type in Ahlmann's classification. Results of measurements on 18 markers are given in tables. The most conspicuous features of the transverse profile are the very rapid increase in velocity across the marginal zones and the presence of a central zone, 400 m wide, in which the velocity is approximately constant. Along the longitudinal profile the glacier is in a state of extending flow, which is consistent with Nye's concept. Vertical movement measurements show that the direction of ice flow is upward relative to the surface although the surface component decreases with distance down the glacier. Melting observations were also made, and an estimate of ice thickness was derived from measurements of surface slope. — V. S. N.

185-299. Brockamp, Bernhard. Erweiterter Nachtrag zu den wissenschaftlichen Ergebnissen der Deutschen Grönland-Expedition Alfred Wegener [Expanded supplement to the scientific results of the Alfred Wegener German Greenland expedition]: *Deutsch. Geod. Komm. Veröffentl.*, ser. B, no. 48, 76 p., 1959.

The first part of this paper reports results of measurements of altitude and temperature made during several traverses from the coast to the "Eismitte" station in the center of the Greenland Ice Cap. Two profiles are reproduced, West Station-Eismitte and north route.

The second part reports results of measurements of ice thickness and temperature. The ice thickness calculated from Bouguer gravity anomalies is 1,510, 1,820, and 2,815 m for points 82, 120, and 300 km inland, respectively. Seismic refraction and reflection surveys showed that the thickness of the firn (firn depth = depth where ice density reaches 0.91) is 40-50 m at 42 km inland, 100 m at 62 km, 140-150 m at 120 km, and, by extrapolation, about 350 m at the center of the icecap. Elastic wave velocities in the ice show a temperature effect: At 0°C, longitudinal wave velocity is 3.60 km/s and transverse wave velocity is 1.68 km/s; at -6.5°C, corresponding velocities are 3.72 and 1.75 km/s; at -10°C, 3.80 and 1.8 km/s; and at -18°C (150 m deep), 4.0 and 1.85 km/s. A pressure effect surely must also exist, but could not be ascertained from the seismic measurements.

Plasticity also is affected by temperature. The viscosity coefficient η is $1 \times 10^{-14} \text{ g cm}^{-1} \text{ sec}^{-1}$ for glacier ice at melting temperature, and $1 \times 10^{-15} \text{ g cm}^{-1} \text{ sec}^{-1}$ at 24 m depth, where the temperature is -14°C . The ice surface closely reflects bedrock topography nevertheless. Near the coast where the ice is quite plastic throughout and under high lateral pressure, no long or large spaces can exist; they are constantly filled in and corresponding valleys appear at the ice surface. — D. B. V.

185-300. British Glaciological Society. Field work: Ice, British Glaciological Soc. News Bull., no. 7, 16 p., 1961.

Reports on some of the projects carried out by the Subcommittee on Glaciology of the Associate Committee on Geodesy and Geophysics, National Research Council of Canada, in the summer of 1960 are summarized briefly. Areas in Canada, Alaska, the Arctic, Norway, Switzerland, and the Antarctic are included. The work on inventory of Canadian glaciers, and photogrammetric and laboratory studies are summarized also. Full reports will be published in the Canadian Geophysical Bulletin for 1960. — V. S. N.

Vallon, Michel. Thickness of the Tacul glacier (Mont Blanc massif). See Geophys. Abs. 185-548.

GRAVITY

185-301. Goguel, Jean. Calcul de l'attraction d'un polygone horizontal de densité uniforme [Calculation of the attraction of a horizontal polygon of uniform density (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 116-127, 1961.

The vertical component of the gravitational attraction exerted by a horizontal homogeneous polygon is obtained as the sum of terms proportional to the difference, for each of the vertices, between the external angle and its spherical perspective. A set of 5 computation charts is presented, each for a fixed value of the angle of the polygon, that give the difference between the external angle and its spherical perspective as a function of the quotient of the distance from the sides to the vertical through the station over the depth. The chart for the right angle is an alinement chart, permitting a rather accurate reading; the others are graphs in rectangular coordinates.

For a distant station the result would be obtained as a small difference between relatively large quantities, and hence would not be very precise; for such stations it is preferable to assume that the entire mass is concentrated at the center of gravity. — D. B. V.

185-302. Lambert, Walter D. Note on the paper of A. H. Cook, "The external gravity field of a rotating spheroid to the order of e^3 ": Royal Astron. Soc. Geophys. Jour., v. 3, no. 3, p. 360-366, 1960.

In the paper in question (see Geophys. Abs. 180-179), Cook's formulas for the potential of a rotating spheroid stop with the term in $P_6(\sin \phi)$, which is given to an accuracy of e^3 . This note states, without proof, formulas for the coefficients of $P_{2n}(\sin \phi)$ with no limit on n and no limit to the formal numerical accuracy of such coefficients. It is also suggested that some of Cook's other formulas may be simplified by a slight change in notation. — D. B. V.

- 185-303. Boaga, Giovanni. Sulla determinazione della densità media del Geoide per mezzo di gravità osservate a latitudini diverse [On the determination of the mean density of the geoid by means of gravity observed at different latitudes]: *Accad. Naz. Lincei Atti Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 3, p. 316-320, 1959.

Using Somigliana's formula for the gravity field of an ellipsoid of rotation and gravity values observed at 20 places covering a wide range of latitudes and longitudes, the mean value of the density of the geoid is calculated to be 5.5174 ± 0.0002 . This agrees well with the value of 5.52 obtained experimentally and accepted by the International Union of Geodesy and Geophysics, and with the value of 5.516 ± 0.005 given in the "Handbuch der Geophysik," which is an average of 7 values. This demonstrates from another point of view the great practical importance of Somigliana's formula. — D. B. V.

- 185-304. Coloma Pérez, Antonio. Sobre las estructuras corticales plano-paralelas [On plane-parallel crustal structures]: *Rev. Geofísica*, v. 19, no. 73, p. 1-12, 1960.

The relationships found by Lozano Calvo are generalized for use in the case of horizontal crustal layering. A formula is given for density of the upper medium, bounded by the surface of the earth, which is shown to be independent of the other mediums so far as the formula is concerned. Formulas are also given for the thickness of the second layer and for the depth to the first discontinuity. Difficulties encountered in applying these formulas in the Segovia region of Spain and steps taken to overcome these difficulties are described. — D. B. V.

- 185-305. Misra, Markandeya. Some axially symmetric empty gravitational fields: *India Natl. Inst. Sci. Proc.*, v. 26, pt. A, no. 6, p. 673-680, 1960.

An axially symmetric gravitational field has been considered in oblate spheroidal coordinates. It is well known that one of the field equations for an empty space-time in case of axially symmetric gravitational fields is the Laplace equation. Three special solutions of the field equations $T^{\alpha}_{\beta} = 0$ have been obtained. Considering the motion of test particles two of the solutions are identifiable as the relativistic analogues of the Newtonian field due to an oblate spheroidal homoeoid and the field due to a homogeneous oblate spheroid respectively. The equations of motion to the first order of approximation reduce to the well-known Newtonian form. — Author's abstract

- Arnold, Kurt. Contributions to gravimetric geodesy. See *Geophys. Abs.* 185-249.

de Graaff-Hunter, J[ames]. The shape of the earth's surface expressed in terms of gravity at ground level. See *Geophys. Abs.* 185-253.

- Beck, A[lan] E. Energy requirements of an expanding earth. See *Geophys. Abs.* 185-262.

Coloma Pérez, Antonio. On the potential of attraction of a nonhomogeneous sphere. See *Geophys. Abs.* 185-345.

- 185-306. Danes, Z. Frankenger. On a successive approximation method for interpreting gravity anomalies: *Geophysics*, v. 25, no. 6, p. 1215-1228, 1960.

A new method of quantitative interpretation of gravity anomalies is presented. The disturbing body is represented by a finite number of vertical prisms arranged on a predetermined, regular grid. The horizontal dimensions of individual prisms are small enough that they can be approximated by vertical-line mass elements at the axis of the prisms. Formulas for gravity due to one prism are derived and, for the case of Gulf Coast salt densities, plotted on a graph. Gravity due to the whole body is an algebraic sum of the contributions of all prisms at the appropriate depths and distances. Direct interpretation is possible by successive approximations, introducing proper geologic limitations. The method is particularly suitable for features with a predominantly vertical dimension such as salt domes and igneous plugs. Accuracy is as good or better than that of graphical dot chart methods, and with a digital computer (on which all the numerical work can be done conveniently) should be about a thousand times faster. — D. B. V.

- 185-307. Pham-Van-Ngoc. Prospection gravimétrique par mesure directe des dérivées secondes verticales de l'intensité de la pesanteur [Gravimetric prospecting by direct measurement of the vertical second derivatives of the intensity of gravity]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 18, p. 1889-1891, 1960.

Vertical second derivatives of gravity can be measured in the field by a new technique proposed by Cagniard which gives the "pseudoderivatives" more precisely than current methods of calculation. If M_1, M_2, \dots, M_n are the points of a regular polygon with n sides inscribed in a circle of radius r , the pseudoderivative (C) of gravity (g) at the center (O) of the polygon for horizontal ground would be $C = 4/nr^2 [ng(O) - g(M_1) - g(M_2) - \dots - g(M_n)]$. The grouping and spacing of stations is chosen to suit the terrain and object of exploration; for instance, in petroleum prospecting an equilateral triangle and $r = 500$ m could be used, and in mineral prospecting a square and $r = 50$ m or less. The gravimeter is carried from the center to the points to measure the raw differences in g between the $n+1$ stations of the group, and C is calculated from the formula.

The topographic and gravity measurements can be made with maximum precision. Because the measurements of g are "reduced" to an independent local level, the center of the polygon, the Bouguer and free-air corrections (which may be seriously affected by errors in altitude and uncertainties concerning density) are dispensed with entirely. The topographic corrections, generally very small, can be calculated totally to combine simplicity, rapidity, and precision. A chart is given for the topographic corrections for the case of an equilateral triangle grouping. — D. B. V.

- 185-308. Halushko [Galushko], P. Ya. Analiz zalezhnosti Izostatichnykh anomalii vid budovy zemnoyi kory v oblasti okeanichnykh prostoriv [Analysis of the dependence of isostatic anomalies on crustal structure in regions of oceanic expanses (with Russian summary)]: Akad. Nauk Ukrain. RSR Heol. Zhur., v. 20, no. 5, p. 18-29, 1960.

Isostatic anomalies over oceans do not truly reflect the quantitative distribution of mass in the crust. Isostatic reductions should be replaced by the method of structural compensation described in this paper. Calculations show that in the reduction of gravity observations at sea the density of the compensating mass should be 0.4 g per cm^3 , which is the difference between the density (3.2 g per cm^3) of the part of the subcrustal layer lying above the depth of compensation and that of the crustal mass (2.8 g per cm^3) above it. A structural reduction is illustrated for Vening Meinesz' profile no. 16 across the

Indonesian Archipelago. In this reduction broad fields of positive anomalies are absent, but the belts of negative anomalies include the deep sea trenches. Structural anomalies are easily interpreted by introducing suitable changes in the structurally compensated model to bring the disturbed field to uniformity. — D. B. V.

- 185-309. Kazinskiy, V. A. Interpretatsiya gravitatsionnykh poley, porozhdayemykh krutopadayushchimi geologicheskimi telami [Interpretation of gravity fields produced by steeply dipping geologic bodies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 595-601, 1961.

The approximation theory of geophysical anomalies and reductions based on an oblique coordinate system is analysed mathematically and discussed. The anomalies and reductions for steeply dipping geologic bodies of arbitrary form are considered, and a mathematical technique is developed that saves substantial time and labor in evaluation and interpretation of anomalies. — A. J. S.

- 185-310. Graf, Anton, and Schulze, Reinhard. Improvements on the sea gravimeter Gss2: Jour. Geophys. Research, v. 66, no. 6, p. 1813-1821, 1961.

Improvements on the Askania "Sea Gravimeter Gss2 after Graf" that have considerably widened the scope of application of the instrument are described, particularly the results of the heavier damping used. Accelerations of up to $\pm 100,000$ mgal produced in the laboratory caused discrepancies of only about 2 mgal between the static and mean dynamic values. Completely irregular accelerations with peaks up to 200,000 mgal yielded dynamic mean values that did not deviate appreciably from the static value. With the new gyro-stabilized platform it is possible to obtain accurate results even in rather rough seas. All the disturbing effects predicted by theory can now be either eliminated by suitable measurement procedure or else accounted for. — D. B. V.

- 185-311. Harrison, J[ohn] C. The measurement of gravity at sea, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 211-229, 1960.

The instrumental difficulties in the measurement of gravity at sea and the history of sea-going gravimeters are discussed briefly. The Vening Meinesz pendulum apparatus has proved to be very reliable when used on submarines. For various operational reasons and because of the lengthy computations needed, the pendulum apparatus is being replaced rapidly by gravimeters for measurements at sea. Theoretical considerations of gravimeters to be used at sea are discussed, and it is concluded that such a gravimeter may be stabilized along the true vertical or be allowed to swing in a gimbal suspension; corrections to be made in each case are summarized. Brief descriptions of the Graf, LaCoste, and vibrating-string gravimeters are given. — V. S. N.

- 185-312. Sazhina, N. B. Ob oshibkakh morskoi gravimetricheskikh opredeleniy na nadvodnykh sudakh [Errors in gravimetric determinations at sea on ships]: Razvedochnaya i Promyslovaya Geofizika, no. 23, p. 70-73, 1958.

Pendulum surveys were made in the Caspian Sea during 1935-36 and 1949-51. The coastal regions of the Azerbaijan S.S.R. have subsequently been surveyed more accurately with bottom gravimeters. The results of the two methods are compared. The errors in the pendulum determinations are attributed to roll of the ship and miscalculation of geographic position. — J. W. C.

- 185-313. Damrel, J. B. The effect of temperature and time on the scale factor of the Worden Gravity Meter: *Boll. Geofisica Teor. ed Appl.*, v. 2, no. 8, p. 567-573, 1960.

For the purpose of checking the scale factors of the Worden Gravimeter at various temperatures, tests were made on several instruments. All calibration tests were made on a test calibrator at element temperatures ranging from 40°C to 50°C. The results indicate an increase in scale factor with increase in element temperature of approximately 0.13 percent per °C. Tests to determine the effect of time on the scale factor indicate that there is no change in scale factor with time as such. There is a decrease in scale factor, however, with a change in the pressure inside the element container assembly. This change in pressure is a function of time, but will vary widely from instrument to instrument depending upon the degree of vacuum integrity of the evacuated system. Also, the gradual change in pressure inside the evacuated container has direct influence upon the thermal drift characteristics. Some obvious precautions are proposed to aid in obtaining higher quality gravity data. — V. S. N.

- 185-314. Tulin, V. A. Термостат с непрерывным регулированием [Thermostat with continuous control]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1499-1503, 1960.

A thermostat for continuous control of temperature of the element assembly of gravimeters was constructed and tested. The theory of the instrument is discussed and practical suggestions given for its adjustment. With a change of 32°C in the ambient temperature, a control coefficient of the order of 500 was attained when the amplification coefficient of the amplifier was about 1,000 and no compensation introduced. — A. J. S.

Bulakh, Ye. G. Application of electric calculating machines for interpretation of magnetic and gravity anomalies. See *Geophys. Abs.* 185-477.

- 185-315. Grossmann, Walter. Bestimmung der Schwereunterschiede Zwischen europäischen Flughäfen mit einem Askania-Gravimeter GS 12 [Determination of the gravity differences between European airports with an Askania GS-12 gravimeter]: *Deutsch. Geod. Komm. Veröffentl.*, ser. B, no. 66, 36 p., 1960.

Gravity measurements were made during 1958-60 at various airports in western Europe in order to connect first order stations of the European network. Observers carrying an Askania GS-12 gravimeter made numerous trips by commercial airlines and took their measurements during scheduled stops. The good internal agreement of the results indicates that this instrument is well suited to large scale measurements with transport by air between stations. — D. B. V.

- 185-316. Robertson, H. W., and Garrick, R. A. Gravity measurements in New Zealand with the Cambridge pendulum apparatus: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 626-642, 1960.

A framework of 19 gravity reference stations was established in New Zealand during 1947 and 1948 using the Cambridge pendulum apparatus. The gravity values, referred to the Cambridge (England) value of 981,250.0 mgal, were obtained by swinging the 6 pendulums at Cambridge before and after the New Zealand observations were made. Full details of the results and station locations are given. — D. B. V.

- 185-317. Algermissen, S. T. Underground and surface gravity survey, Leadwood, Missouri: *Geophysics*, v. 26, no. 2, p. 158-168, 1961.

A surface gravity survey consisting of 214 stations covering approximately 4 sq mi was conducted over and adjacent to the North Leadwood Mines at Leadwood, Mo. A corresponding survey of 278 stations was carried out in the mine workings. A method of reducing underground gravity observations is outlined. The principal factors limiting the accuracy of the underground observations are given. Methods for determining rock densities are described. A comparison of the surface and underground gravity maps shows that major Precambrian knobs were revealed by both surveys. Smaller structures not shown on the surface map were revealed by the underground survey. Anomalous density areas between the level of the two surveys were easily located. — Author's abstract

- 185-318. Ghigone, João Ítalo. Reconhecimento gravimagnético na Bacia de Pelotas [Gravity and magnetic reconnaissance in the Pelotas Basin]: *Bol. Tecn. Petrobrás*, v. 3, no. 2, p. 73-78, 1960.

The first geophysical work in the Pelotas sedimentary basin in Rio Grande do Sul, Brazil, was carried on in 1959. Gravity and magnetic measurements were made along 5 profiles from the crystalline shield to the ocean; 953 stations were occupied. A Worden gravimeter and two Schmidt vertical magnetometers were used. The results are presented in the form of 5 gravity profiles with corresponding interpretation of basement relief, a figure showing more detailed magnetic and gravity anomalies along a portion of the Jaguarão profile, and a map of Bouguer anomalies. The maximum thickness of the sediments is about 1,400 m. — D. B. V.

- 185-319. Hales, A. L., and Gough, D. I. Isostatic anomalies and crustal structure in the Southern Cape: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 225-236, 1960.

In a previous paper it was suggested that the tendency of the isostatic anomalies to be systematically negative on the seaward side of the great escarpment which lies about 200 km from the eastern and southern coasts of South Africa could be explained in terms of compensation of topography removed by erosion (see *Geophys. Abs.* 180-227, 182-352). In this paper one of the negative anomaly zones in the Southern Cape is examined in detail, and it is found that at least 1.4 km of material has been removed over a strip 80 km wide. The resulting stress differences are of the order of 2.3×10^8 d per cm^2 if the load is being carried by both crust and mantle. If the crust is floating on the mantle, the stresses in the crust are of the order of 120×10^8 d per cm^2 in the center of the strip.

One of the noteworthy features of the gravity map of South Africa is a number of positive anomalies associated with the Bushveld complex. The gravity picture supports Cousins' view that the mafic rock of the complex do not form part of a lopolith but lie in two deep troughs. Assuming that the extra load due to the mafic rocks is uncompensated, their minimum thickness is estimated to be of the order of 7 km (for a density difference of 0.3 g per cm^3). — D. B. V.

- 185-320. Jones, L., Mathieu, P. L., and Strenger, H. Gravimétrie [Gravimetry]: *Mus. Royal Congo Belge Annales Ser. 8, Sci. Geol.*, v. 36, 46 p., 1960.

A gravimetric survey of the Congo Basin made between 1952 and 1955 is reported. The equipment, procedures, and methods of calculation are described. Results are presented in a Bouguer anomaly map. — D. B. V.

- 185-321. Gerke, Karl, and Watermann, Heinz. Übersichtskarten der Schwere und der mittleren Höhen von Westdeutschland 1:4,000,000 [Generalized maps of gravity and mean altitudes of West Germany, 1:4,000,000-scale (with English and French summaries)]: Deutsch. Geod. Komm. Veröffentl., ser. B, no. 46, pt. 3, 19 p., 1960.

The series of general gravity maps of West Germany is concluded with four 1:4,000,000-scale maps, printed in 3 colors, that show Bouguer (2 maps), free air, and isostatic (Airy, $T=30$ km) anomalies. One Bouguer map was generalized from the 1:1,000,000 scale map and the other, practically identical, was obtained by interpolating isoanomalies using the representative values of $6' \times 10'$ grid squares. The free-air anomaly map was similarly obtained by interpolation, whereas the isostatic anomalies were partly obtained by interpolation, partly calculated from Bouguer anomalies, and partly taken from existing maps. A fifth map shows mean altitudes for $12' \times 20'$ grid squares for West Germany and surrounding regions. — D. B. V.

Ramsayer, K[arl]. Report about gravity reduction of the leveling network in Baden-Württemberg. See Geophys. Abs. 185-257.

- 185-322. Oelsner, Christian. Schweremessungen unter Tage [Gravity measurements underground (with English and Russian summaries)]: Zeitschr. Angew. Geologie, v. 6, no. 4, p. 172-177, 1960.

After a review of the literature concerning gravity investigations in mines, a study designed to limit the possibilities of interpretation in a given case is described. The survey in question was made in the Otto Brosowski mine in the Mansfeld basin of East Germany in an attempt to locate thin salt bodies. The results are presented in the form of maps of Bouguer anomalies on level 7 and at the surface, a gravity profile along level 7, U_{zzz} maps at the surface and a block density map for the depth interval between the surface and level 7. Any distinct mass deficit thus revealed probably represents a salt intercalation. — D. B. V.

- 185-323. Scheffer, V[iktor]. Some contributions to the geophysical knowledge of the Carpathian basins [with French, German, and Russian summaries]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 423-461, 1961.

The structure of the northeastern Carpathians and their outer foreland is interpreted with the help of gravity and magnetic data. Ten maps (including Bouguer anomalies of central Europe, vertical magnetic anomalies in the Great Hungarian Plain, gravity anomalies and main tectonic lines in East Slovakia, geotectonic elements of the northern part of the Great Hungarian Plain, and several maps of structural and drainage elements), three block diagrams, and a gravity profile across the northwestern Carpathians are given. — D. B. V.

- 185-324. Balavadze, B. K., and Tvaltvadze, G[uri] K. Stroyeniye zemnoy kory Zakavkasko-Kaspiyskoy vpadiny po geofizicheskim dannym [Crustal structure of the Transcaucasian-Caspian depression according to geophysical data (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 82-90, 1960.

Crustal structure in the Transcaucasus depression and Caspian Sea basin has been interpreted from gravity and seismic data. Differences in apparent velocities in different directions from epicenters of local earthquakes are attributed to variations in depth of crustal discontinuities. Layer thicknesses and velocities and gravity anomalies along a profile from Anaklia on the Black Sea to Karshi on the east shore of the Caspian Sea are shown in a diagram. — D. B. V.

- 185-325. Garetskiy, R. G., and Shraybman, V. I. Glubina zaleganiya i stroeniye skladchatogo fundamenta severnoy chasti Turanskoy plita (Zapadnyy Kazakhstan) [Depth of occurrence and structure of the folded basement of the north part of the Turan plate (west Kazakhstan)]: Akad. Nauk SSSR Geol. Inst. Trudy, no. 44, 90 p., 1960.

The fourth chapter of this work is devoted to the results of geophysical investigations of west Kazakh S. S. R. in the area centered around the Aral Sea. The depth to basement is calculated on the basis of magnetic, gravity, and electrical data. There is in general a direct relationship between gravity maximums and uplifts of the surface of the basement; minimums correspond to downwarps. Where a gravity maximum does not correspond to an uplift on the basement, it is accompanied as a rule by intensive magnetic anomalies, which indicate the presence of dense, magnetic rocks. Several maps and profiles are presented. — J. W. C.

Kharechko, G. E. On the problem of the structure of the Russian platform in the area of the cities Berdyansk and Nogaysk (according to the data of geophysical investigations). See Geophys. Abs. 185-555.

- 185-326. Marussi, A[ntonio]. Les resultats des recherches géophysiques de l'expédition italienne au Karakorum, 1954-1955 [The results of the geophysical investigations of the Italian expedition to the Karakorum, 1954-1955]: Ciel et Terre, v. 75, no. 7/8, p. 237-245, 1959.

The thickness of the Baltoro glacier in the Karakorum range was measured in two ways by the Italian expedition of 1954-55: by Somigliana's method, based on photogrammetric measurements of the rate of ice movement along transverse sections, with the assumption that the bottom is semielliptical in shape; and by calculation from gravity anomalies measured along transverse profiles. The gravimetric results are shown in graphs.

A detailed gravimetric survey was made of the area traversed by the expedition, using Worden gravimeters; 300 stations were occupied covering all the western Karakorum, the Dardisan, the Swat, and the Hindu Kush south of the Pamir. This survey fills a gap in the regional gravity map of central Asia. A sketch map of isostatic anomalies for central Asia (Airy, $T=30$ km) shows that the Fergana, Tadzhik, Kucha, Yarkand, and Indo-Gangetic depressions are related to marked negative anomalies as expected; however, these anomalies are too large to be explained solely by the lower density of the sedimentary fill and therefore suggest deeper structural anomalies.

Strong negative anomalies along the axis of the Karakorum, bordered on both sides by positive anomalies, suggest the presence of a core of granitic material that is compact but of density lower than that of the sediments. This view is supported by Russian seismic measurement in the Pamir, which shows a thickening of the granite layer (more than 30 km) coinciding with strong negative anomalies. Granitic intrusions of this type not only might explain the vertical isostatic uplift of the Karakorum but also the horizontal movements of folding and overthrusting in the outer part of the range. — D. B. V.

- 185-327. Hofman, B. J. Gravimetric basepoints in the Digoel area, Netherlands New Guinea: *Nova Guinea*, n. s., v. 10, pt. 1, p. 149-158, 1959.

Between May 1956 and June 1957 a widespread network of gravimeter stations was established over an area of 100,000 sq km in the Digoel area, Netherlands New Guinea, from the Bloemen River in the west to the Merauke River on the Dutch-Australian border. The network was established for determining the regional geologic structure. Results are given in tables and on an isostatic anomaly map. — V. S. N.

McMutrie, I. H., and Moorcroft, E. Gravity and magnetic traverses over aeromagnetic anomaly—hundred of Carina. See *Geophys. Abs.* 185-483.

Talwani, Manik, Worzel, J. Lamar, and Ewing, Maurice. Gravity anomalies and crustal section across the Tonga Trench. See *Geophys. Abs.* 185-363.

- 185-328. Bull, C. Gravity observations in the Wright Valley area, Victoria Land, Antarctica: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 543-552, 1960.

Gravity measurements were made during an east-west traverse from the coast of McMurdo Sound near Marble Point, across the Wilson Piedmont glacier and the Lower Wright glacier toward the head of Wright Valley. The Bouguer anomaly along this line ranges from -10 mgal at the coast to -80 mgal at the western edge of the Lower Wright glacier and -110 mgal at the head of the valley. The gravity gradient is 5 mgal per km near the coast and 1 mgal per km along the valley. — D. B. V.

HEAT AND HEAT FLOW

- 185-329. Clark, Sydney P., Jr. Heat flow from a differentiated earth: *Jour. Geophys. Research*, v. 66, no. 4, p. 1231-1234, 1961.

Calculations are made of the heat flow from an initially cold earth with radioactivity distributed uniformly through a surface shell, with account taken of radioactive decay. It is found that the heat flow exceeds the heat produced by about 10 percent if the abundances of radioactive elements are the same as in chondrites and the radioactive shell is less than about 300 km thick. The heat flow calculated in this way exceeds the observed value, but neither figure is considered known accurately enough to warrant rejection of the chondrite model of the earth. — Author's abstract

- 185-330. Clark, S[ydney] P., Jr. Geothermal calculations: *Carnegie Inst. Washington Year Book* 59, p. 144-147, 1960; reprinted in *Carnegie Inst. Washington Geophys. Lab. Ann. Rept. of Director for 1959-1960*, 1960.

The problem of the cooling of a radioactive sphere can be broken down by the principle of superposition into two simpler problems: (1) Temperatures are calculated for a sphere at some low, uniform temperature with heat produced by radioactive decay; and (2) temperature is taken to be some function of radius initially, and it is assumed that there is no heat production. In both, the surface of the sphere is assumed to be maintained at zero for all time and the temperature is assumed to depend on radius only. The sum of the temperatures calculated is then the temperature in a sphere with heat production and with a nonzero initial temperature.

Some limits can be set to the effects of radiative transfer and other processes that lead to high thermal conductivity at high temperatures from earth models with nonuniform thermal conductivity. Definite information about temperatures at shallow depths is derived from a model sphere composed of an outer shell with a finite conductivity surrounding the core (not the seismically determined core) in which thermal conductivity is infinite, and from contrasting it with a more conventional model in which conductivity is assumed to be uniform. With uniform conductivity there is no thermal gradient at great depth if heat production is uniform, and cooling can be achieved only by changing the model. A thermal gradient can be set up by supposing that partial fusion and resulting mass transfer took place, and then cooling at all depths becomes possible. It appears, however, that the cooling of the deep interior always must be slight.

Earth models are commonly based on the assumption that initial temperatures were the temperatures of solidification, at least throughout the mantle. The discussion presented here suggests that the temperatures at present are within a few hundred degrees of such initial temperatures, and, thus, the problem of calculating temperatures at great depth becomes the problem of estimating the initial temperatures. — V. S. N.

185-331. Ringwood, A. E. Some aspects of the thermal evolution of the earth: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 241-259, 1960.

Empirical data relating to the thermal history of the earth are examined. Recent astronomic and geochemical evidence strongly suggests that the earth formed by accretion from an initially low-temperature gas-dust cloud of solar composition. The distribution of U, Pb, Th, and K within the earth implies that it passed through a melting or partial melting process about 4.5×10^9 yr ago. This conclusion is confirmed if the core is assumed to consist dominantly of iron-nickel. Formation of the core, which likewise occurred about 4.5×10^9 yr ago, would liberate sufficient gravitational energy to cause melting. Evidence in favor of melting is also provided by analogy with meteorites.

Of the possible causes of this early melting, gravitational energy is considered to be chiefly responsible. Radioactive heating does not appear to be important. A metallic phase is produced by reduction due to interaction of accreting dust falling with high velocity into the primitive reducing atmosphere surrounding the earth.

The distribution of temperature within the earth 4.5×10^9 yr ago will be given by the melting-point gradient. Recent data on the electrical conductivity of the mantle and the melting point of materials under high pressures suggest that the present temperature distribution is much less than the melting point gradient. This implies that the earth has cooled considerably. The inferred cooling is consistent with present data on the abundance of radioactive elements in meteorites and in the earth, and also with possible modes of internal heat transfer, particularly convection and radiation. — D. B. V.

185-332. Lyubimova, Ye. A. K voprosu o razogrevanii Zemli [On the problem of the heating of the earth (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, *Doklady Sovet. Geologov*, Problema 2, sec. 2, p. 14-19, 1960.

Calculations show that it is unlikely that heat loss due to convection currents can result in cooling of the earth, otherwise observed heat flow would be greater than it is. The presence of a thermal conductivity minimum at about 50 km depth prevents intensive heat loss from the interior, allowing gradual accumulation of heat from radioactive sources. The earth should be expanding slightly at a rate of about 1 cm of radius per thousand years; in the

past the rate of expansion might have been greater (5-10 m per thousand years). Expansion should eventually cease. The amount of expansion is inadequate to explain continental drift, but it might account for the formation of deep fractures along which magma can ascend. — D. B. V.

Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core. See *Geophys. Abs.* 185-376.

185-333. Bullard, E. C. Measurement of temperature gradient in the earth, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 1-9, 1960.

The techniques and instruments employed in measurements of the temperature gradient of the earth in boreholes, in mines and tunnels, and in sediments beneath the ocean floor are discussed. Factors that produce variations in the temperature gradient are mentioned, and it is noted that no useful purpose is served by attempting to make very accurate measurements of the gradient; the elimination of gross systematic errors is much more important. — V.S.N.

185-334. Misener, A. D., and Beck, A[lan] E. The measurement of heat flow over land, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 10-61, 1960.

Some of the more important methods of determining the pattern of terrestrial heat flow are described in detail, and the physical limitations of the methods are discussed. To find the flux occurring locally, the temperature gradient and the thermal conductivity of the rocks in the area are determined; if the dimensions of the area are small in comparison to the dimensions of the earth and if there is no horizontal variation of constituents, the flow of heat may be considered linear and the flux is the product of the temperature gradient and the thermal conductivity. A correction is applied to allow for effects of the geological history and thus to arrive at a value for the equilibrium heat flux.

The types of thermometers used in the measurement of temperature gradients are described and the field use for each type of equipment discussed. Laboratory and field methods of measurement of thermal conductivity are presented in detail, and, lastly, the methods of combining gradient and conductivity to calculate heat flux are discussed. The effects of ice ages, uplift and erosion, topography, and local sources of heating on the equilibrium heat flow are also treated. — V. S. N.

185-335. Moses, P. L. Geothermal gradients now known in greater detail: *World Oil*, v. 152, no. 6, p. 79-82, 1961.

Temperature-depth relationships are presented for many active oil-producing areas of the United States and Canada. Where sufficient data are available, the information is presented on a map showing isothermal gradient lines. Data on other areas are listed in a table. This compilation is an updating of the earlier work by Nichols (see *Geophys. Abs.* 127-8890). Temperatures were obtained from glass maximum recording thermometers, and the measurements were made in conjunction with bottom-hole pressure surveys and subsurface sampling. The readings were made in wells that had been completed for periods of several days to several years. Temperature increase with depth is approximately linear in most places. — J. W. C.

185-336. Cheremenskiy, G. A. *Geotermicheskiye issledovaniya v Sibiri* [Geothermal investigations in Siberia]: Akad. Nauk SSSR, Inst. Merzlotovedeniya Trudy, v. 15, p. 132-143, 1959.

Geothermal investigations made in boreholes in Siberia from 1939 to 1954 are reported. Isothermal profiles are presented, and isothermal maps show the temperature gradient to depths of 500 and 1,500 m. The geothermal step ranges from 13.4 to 34.6 m per °C in the various regions of Siberia in the interval between 100 and 1,000 m. The configuration of the geothermal surfaces corresponds in general to that for the surface of the basement. — A. J. S.

- 185-337. Dean, Christopher. Using nuclear resonance to sense temperature: *Electronics*, v. 33, no. 28, p. 52-54, 1960.

A temperature-sensing system is described that has constant calibration as long as the associated electronics operate. The spectra used are nuclear quadrupole resonance (NQR) r-f absorption lines whose frequencies decrease smoothly with temperatures. This relation is essentially fixed for all samples of the selected material indefinitely. An electronic spectrometer is used to locate the NQR frequency and then transmit it. The monitoring station measures the frequency and makes the conversion to temperature, thus assuring reliability. Precision with the circuitry described is a few tenths of a degree. More elaborate equipment for laboratory measurements can attain a precision of a few thousandths of a degree.

The unique properties of the NQR temperature-measuring technique, even with its drawbacks, makes it invaluable for such uses as a permanent unmanned weather station, long-range space exploration, and continuous measurements on the ocean floor or in a drill hole. The probe would deliver well-calibrated telemetered data for such applications for long periods of time, the length depending on the life of the electronic components and power supply.

An excellent probe material is KClO_3 . It is stable and has a singlet spectrum (relatively narrow line-width compared to the rate of change of NQR frequency with temperature). Resonance frequency = 28.2134 Mc, line width = 500 cycles per second, and rate of change = -4.8 kc per °C at 0°C.

The NQR instrument described is a self-quenched super-regenerative r-f spectrometer. Other spectrometers have been used for NQR that are basically similar to grid-dip meters.

References to related theory and other equipment are given. — H. C. S.

- 185-338. Lewis, Donald R., Whitaker, Thomas N., and Chapman, Carl W. Thermoluminescence of rocks and minerals. Pt. 1. An apparatus for quantitative measurement: *Am. Mineralogist*, v. 44, no. 11-12, p. 1121-1140, 1959.

Equipment which permits quantitative recording of the thermoluminescence emitted by samples with a high degree of reproducibility and sensitivity has been developed. The equipment operates over the temperature range from 25°C to 600°C at rates from 10°C per min to 100°C per min. The apparatus has high light-detection sensitivity and broad spectral response. The construction combines reliability and flexibility with simplicity of operation. Not more than 50 mg of sample is ordinarily required.

An analysis of the instrumental and physical factors which determine the precision of making glow curves is made to evaluate the requirements for each section of the apparatus. — Authors' abstract

- 185-339. Thompson, G. K. Shallow temperature surveying in the Wairakei-Taupo area: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 553-562, 1960.

The 1-m temperature probe has proved of value in indicating the boundaries of subsurface heat storage in the Wairakei geothermal power area in New

Zealand. It provides a method of rapid reconnaissance, indicating areas worthy of further investigation by drilling. In general the 1-m temperature contours correlate well with isotherms obtained from borehole temperature measurements. — D. B. V.

- 185-340. Bell, J. D., Crooks, R. C., Holser, W. T., Sachsel, G. F., Williams, J. R., Ribbert, R. B., Jr., and Stone, J. J., Jr. Availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 27, 56 p., 1959.

The availability of geothermal energy is surveyed, and its potential use in the demineralization of saline water is evaluated. The investigation covers a summary of available geothermal data, a mathematical analysis of the potential availability of geothermal energy, and an analysis of some engineering mechanisms of importance in the utilization of geothermal energy. — V. S. N.

- 185-341. MacDonald, J. R., Stensaas, E. R., and Stafford, P. M. Investigation of the availability of geothermal energy for the demineralization of saline water in the Black Hills Region, in Investigation of the availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 28, pt. 1, p. 1-24, 1959.

Data from wells in the Black Hills indicate that thermal gradients are not appreciably higher than the average for the earth's crust except in a few local areas with 2 or 3 times the magnitude; the highest well temperature measured was 168° at a depth of 6,250 feet. This temperature level is low for practical purposes; therefore, the Black Hills region does not offer any unique advantages for extraction of geothermal energy. — V. S. N.

- 185-342. Cope, Joseph H. Investigation of the availability of geothermal energy for the demineralization of saline water in California, in Investigation of the availability of geothermal energy for the demineralization of saline water: U.S. Dept. Interior Research and Devel. Prog. Rept., no. 28, pt. 2, p. 25-43, 1959.

The availability of thermal energy in California is investigated from two aspects: (1) thermal wells, and (2) hydrothermal sources such as hot springs, geysers, and steam wells. The available geothermal data do not show that California has unusually high temperature gradients; the largest value is at Huntington Beach, 49.3°C per km, which is only about twice the mean value of the earth's gradient. Thus, thermal wells are not economically practical sources of thermal energy in California. Of the many hydrothermal sources in California, steam wells offer the nearest approach to a geothermal energy source for demineralization of saline water. (See also Geophys. Abs. 185-341.) — V. S. N.

INTERNAL CONSTITUTION OF THE EARTH

- 185-343. MacDonald, Gordon J. F., and Ness, Norman F. A study of the free oscillations of the earth: Jour. Geophys. Research, v. 66, no. 6, p. 1865-1911, 1961.

Published observations on the toroidal oscillations of the earth are reviewed critically. A supplementary analysis of the record obtained by the Lamont strain seismometer is presented. Eleven toroidal modes are identified, and

it is concluded that the periods are known to within 1 percent. A perturbation scheme involving the ratio of the angular velocity of the earth to the resonant frequency is used in calculating the effect of rotation on resonant frequency. The perturbations of the toroidal oscillations due to core-mantle interaction are treated in detail.

A calculation of elastic energy in the low-order oscillations suggests a value of 10^{18} ergs per cph for the energy density at low frequencies in the Chilean earthquake. Each mode of oscillation has a characteristic radial distribution of elastic energy associated with it; this distribution determines which parts of the earth contribute most heavily in determining a particular resonant frequency. The distribution of energy for the lower 17 modes and the resonant frequencies are calculated for different earth models. The Gutenberg model fits the observations most closely and a slight alteration (lowering the shear-wave velocity in the lower mantle) gives a substantially better fit.

The physical conditions required for the formation of a low-velocity layer are examined in detail. The results confirm Birch's statement (see Geophys. Abs. 151-14075) that a temperature gradient in excess of 6° - 7° per km is needed to produce a decrease in velocity. The temperature need not approach or exceed the melting temperature. If the upper mantle is homogeneous, the low velocity zone should extend from the base of the crust to 150 km under the oceans and 100 km under continental regions. The distribution of thermal conductivity and radioactivity consistent with the low-velocity layer is also considered. — D. B. V.

- 185-344. Boaga, Giovanni. Su talune questioni relative alla funzione di Roche sulla distribuzione della densità nello interno delle Terra [On some questions relative to Roche's function on the density distribution in the interior of the earth]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 2, p. 123-129, 1959.

Calculations show that Roche's hypothesis, based on Clairaut's equation concerning the equilibrium of a rotating fluid mass, does not reproduce all at one time the values actually observed for the different geometric and geophysical parameters of the earth. This should be borne in mind when Roche's hypothesis is applied in geophysical investigations. — D. B. V.

- 185-345. Coloma Pérez, Antonio. Sobre el potencial de atracción de una esfera no homogénea [On the potential of attraction of a nonhomogeneous sphere (With English summary)]: *Rev. Geofísica*, v. 18, no. 70, p. 119-141, 1959.

The laws of density distribution for the earth's mantle and core are analyzed, and approximations are derived for each. Using these approximations and assuming a constant density for the crust, formulas are derived for the potential of attraction of points outside, on the crust, in the mantle, and in the core of a spherical earth. Poisson's equations and the mean density of the core and of the mantle are worked out, and mean density of both core and mantle together is also given. Finally, the moments of inertia in the core and in the mantle with respect to the axis of rotation are calculated. — D. B. V.

- 185-346. Afanas'yev, G. D. Stroyeniye zemnoy kory i nekotoryye problemy petrografii [Structure of the earth's crust and some problems in petrography]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 3, p. 22-35, 1961.

This is a review of geophysical information concerning the nature of the crust and mantle, particularly in the vicinity of the M-discontinuity. The ex-

act petrographic nature of the rocks is still impossible to determine. The contributions of Levinson-Lessing in this field are stressed, and possible lines of future investigation are discussed. — D. B. V.

- 185-347. Shimazu, Yasuo. A note on genesis and upward transfer of parental magma of igneous rocks. A thermodynamical aspect of the earth's interior, Pt. 3: Nagoya Univ. Jour. Earth Sci., v. 7, no. 2, p. 91-97, 1959.

In the genesis and upward transfer of parental magmas, discussed from a thermodynamic view point, heat concentration is more effective in melting rocks than is stress release. Two possible mechanisms of transfer of the magmas are suggested: (1) Hydrodynamic transfer through fissures is effective in orogenic or volcanic processes. The minimum rate of transfer is 30 g per cm² per yr. (2) Zone melting transfer was effective on a global scale during the high temperature period of 0.5-1X10⁹ yr after the birth of the earth. Orogenic processes were not necessarily an accompaniment. About 10⁶ yr are necessary for the magma to float up 100 km, and a concentration of low melting components during the transfer is an important feature. — V. S. N.

- 185-348. Shimazu, Yasuo. A role of water in metamorphism as illustrated by some reactions in the system MgO-SiO₂-H₂O. A thermodynamical aspect of the earth's interior, Pt. 4: Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 86-92, 1960.

The mineral reactions in the MgO-SiO₂-H₂O system are a key to dehydration processes within the primeval earth, and, consequently, discussion of hydration-dehydration reactions in the system is useful for study of global physico-chemical processes which took place during terrestrial evolution as well as for preliminary study of regional metamorphism.

The effects of migration of water vapor upon the thermodynamic state of the MgO-SiO₂-H₂O system is studied, assuming a hydrodynamic flow of vapor and applying the thermodynamics of a steady state. Univariant curves (paragenesis of three minerals) and divariant regions (paragenesis of two minerals) correspond to hypothetical petrograds and metamorphic facies, respectively. Variations in association of metamorphic facies are obtained for various constrained conditions of the following variables: pressure, temperature, and chemical potential of the vapor. — V. S. N.

- 185-349. Shimazu, Yasuo. Physical conditions of contamination and fractionation of basaltic parental magmas: Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 72-85, 1960.

Basaltic parental magmas form within the mantle and move toward the surface; in the process of movement interaction takes place between the cooling magmas and the surrounding solid rocks. The amount of contamination and fractionation that takes place in the magma depends upon the speed of movement and the rate of cooling of the magma. If movement is too slow, magmas will solidify in place without appreciable contamination; if it is too fast, fractionation will not occur. It is calculated that the optimum speed of movement to produce an anorthite-albite binary magma is 1-10 cm per yr. The physical conditions necessary to obtain the optimum speed of movement are also studied, and it is concluded that a floating-up of magmas by zone melting is a possible mechanism. A 6 to 1 ratio of horizontal extent to thickness is the optimum shape of a magma sheet. — V. S. N.

- 185-350. Aldrich, L. T[homas], Asada, T., Bass, M[anuel] N., Hales, A. L., Tuve, M[erle] A., and Wetherill, G[eorge] W. The earth's crust: Carnegie Inst. Washington Year Book 59, p. 202-208, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-1960, 1960.

The seismic studies carried out in 1959-60 as a part of the larger study of Precambrian geologic and tectonic history are reviewed. During the year a network was established which consists of 6 seismic stations in southern Peru, 3 in Bolivia, and 4 in northern Chile with equipment specialized for recording local earthquakes in order to analyze the great attenuation of waves observed across the Andes ranges and the Altiplano.

Preliminary experiments were carried out to determine whether difficulties encountered in using near-vertical reflections for the study of crustal structure could be overcome. This was a continuation of work started in 1958-59 (see Geophys. Abs. 184-427). Reconnaissance seismic studies of earth structures were resumed also in 1959 with observations along azimuths due east from three shot points in Montana and northeast Wyoming. The data observed are presented in three traveltime curves and in a table. — V. S. N.

- Shor, George G., [Jr.], and Fisher, Robert L. Middle America Trench: Seismic-refraction studies. See Geophys. Abs. 185-543.

Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion. See Geophys. Abs. 185-142.

Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean. See Geophys. Abs. 185-587.

- 185-351. Tryggvason, Eysteinn, and Báth, Markus. Upper crustal structure of Iceland: Jour. Geophys. Research, v. 66, no. 6, p. 1913-1925, 1961.

Results are presented of seismic measurements made in 1960 of the thickness and structure of the lava layer that covers all of Iceland. Eight refraction profiles ranging from 20 to 41 km long were made in a line crossing central Iceland from southwest to northeast. The lava layer consists of three sections with longitudinal velocities of 3.7 ± 0.3 , 4.95 ± 0.2 , and 5.55 ± 0.05 km/s. The 3.7 km/s layer is found mainly in the southwest, where the other two are absent. In north Iceland the 4.95-km/s layer is near the surface and the 5.55-km/s layer at a depth of about 2 km. Total lava thickness ranges from 1.73 km in the southwest to 4.81 km in the north. Below the lava the longitudinal velocity is about 6.2 km/s, increasing to 6.7 km/s at a depth of about 5 km. Shear waves were clearly recorded on 3 profiles in north Iceland but were recorded not at all or only faintly elsewhere. — D. B. V.

- 185-352. Choudhury, Mansur Ahmed. Sur la structure générale de la croûte terrestre en Europe occidentale [On the general structure of the earth's crust in western Europe]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 9, p. 1362-1364, 1961.

Crustal structure in western Europe has been studied, using Pn-, Pc-, and Sc-wave data from 28 near earthquakes or explosions. The numerical values of the function F in the equation $Pc-Pn=F\{H, h, (Sc-Pc)\}$ (where H =total thickness of crust, h =focal depth) were calculated for three crustal models: model

A, with constant velocity ($V_p=6.0$ km/s) down to the M-discontinuity; model B, with $V_p=6.0$ km/s to 20 km and 6.5 km/s below that; and model C, with $V_p=6.0$ km/s to the base of the sediments and 6.2 km/s below that. In all cases a value of $V_p/V_s=1.743$, as ascertained from explosion data, was used. Model A best fits the observed data. — D. B. V.

Bisztricsány, Ede, and Kiss, Zoltán. Computation of the mean crustal thickness on a Eurasian path based on Love wave dispersion curves. See Geophys. Abs. 185-143.

185-353. Gal'fi, Ya. [Gálfi, János], and Shtegen, L. [Stegen, Lajos]. Budova zemnoy kory v Ugorshchyni [Structure of the earth's crust in Hungary]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 3, p. 42-46, 1960.

The results of crustal structure investigations in Hungary, mainly by seismic depth sounding, are summarized (see Geophys. Abs. 168-195, 171-212, -213, 173-248). — D. B. V.

Gálfi, János, and Stegen, Lajos. Deep reflections and crustal structure in the Hungarian Basin. See Geophys. Abs. 185-553.

Gálfi, János, and Pálosk, Miklós. Crustal-study refraction profile in the Hungarian Basin. See Geophys. Abs. 185-552.

185-354. Grachev, Yu. N., Dekhnich, M. Ya., Litvinenko, I. V., Nekrasova, K. A., and Sosnovskaya, A. V. Glubinnyye geofizicheskiye issledovaniya na territorii Baltiyskogo shchita [Deep geophysical investigations in the territory of the Baltic shield (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 43-50, 1960.

Combined geophysical methods (including seismic techniques) were used in investigations of the deep structure of the Baltic shield, where the granite layer is well exposed, for the purpose of assessing the possibilities of such an approach in regions where the granite is hidden. Conditions in northern Karelia were found to be favorable for deep seismic sounding. With low-frequency apparatus, deep waves could be recorded several tens of kilometers from the shot point with charges of 20-40 kg detonated in shallow water bodies; for distances greater than 200 km, 400-500 kg charges were needed.

Many longitudinal, transverse, converted, and surface waves were recorded. For many wave groups observations were complete enough to permit the plotting of continuous correlated intersecting traveltime curves and to determine the dynamic characteristics of elastic waves. Discontinuities were clearly recognizable at 10-12 km and 30-40 km. A relationship is apparent between deep-seated and surface structures. The study of the upper 10-12 km of the Precambrian (of interest for the solution of practical problems) by seismic prospecting methods appears to be feasible. — D. B. V.

185-355. Panasenko, G. D. Struktury zemnoy kory Kol'skogo poluostrova po seysmicheskim dannym [Crustal structure of the Kola Peninsula according to seismic data (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 51-55, 1960.

The existence of three active fracture zones in the Kola Peninsula and northern Karelia, recognized earlier on the basis of geologic, geomorphic, and

earthquake data, is confirmed by the records of weak local earthquakes at the Apatity seismic station. Records from industrial explosions show a transverse wave phase that is interpreted as a reflection from a flat-lying horizon.

Analysis of records of distant earthquakes indicates a three-layered crust. The average crustal thickness is about 51 km, which is considerably more than the average for central Europe (27 km). The average thickness of the granite layer is 20 km. The M-discontinuity dips southward. — D. B. V.

- 185-356. Yevseyev, S. V. Zemletrus 20 lyutoho 1951 r. ta budova zemnoy kory v rayonī Zakarpattya [The earthquake of February 20, 1951 and the structure of the earth's crust in the Transcarpathian region]: Akad. Nauk Ukrayin, RSR Heol. Zhur., v. 18, no. 4, p. 112-116, 1958.

Crustal structure in the Transcarpathian region is deduced from arrivals at 21 European seismic stations of P- and S-waves from the Nograd (Hungary) earthquake of February 20, 1951. Yevseyev locates the epicenter at $\phi=47^{\circ}57.4'$ N., $\lambda=19^{\circ}12.9'$ E.; Karník (1953) located it at $\phi=47^{\circ}58.9'$ N., $\lambda=19^{\circ}16.1'$ E. The granitic and the basaltic layers are calculated to be 15 and 29 km thick, respectively, as compared to Karník's corresponding values of 9 and 26 km. — D. B. V.

- 185-357. Neprochnov, Yu. N., Goncharov, V. P., and Neprochnova, A. F. Seysmicheskiye dannyye o stroeniye zemnoy kory v tsentral'noy chasti Chernogo Morya [Seismic data on crustal structure in the central part of the Black Sea]: Akad. Nauk SSSR Doklady, v. 129, no. 2, p. 408-411, 1959.

Seismic depth sounding and echo-sounding surveys were carried out concurrently in the summer of 1958 in the Black Sea south and southeast of the Crimean Peninsula. Three crustal profiles were established, two across the continental slope into the deep sea and one along the central part of the deep sea basin connecting the southern ends of the first two. The results show that there is a granitic layer 4-6 km thick under the continental shelf; it pinches out southward. Under the deep sea basin the crust is two-layered and about 28-30 km thick including the water layer. In one of the profiles across the continental slope, both the top of the basaltic layer and the M-discontinuity dip northward under the granitic layer, the basalt surface sloping from a depth of 12-13 km to a depth of 20 km and the base of the crust from 30-32 km to more than 36 km. In the other profile the basalt surface rises northward to a depth of 10 km not far from the coast off Yalta. In general the crust under the central Black Sea is thicker but otherwise analogous to that southwest of the Crimea outside the continental slope; the difference lies mainly in the thickness of the basaltic layer.

The seismic data help to explain the gravity field of the region; for example, the predominance of positive Bouguer anomalies over the mountains of Crimea (in contrast to other areas of uplifted Alpine geosynclines) can be attributed to the shallowness of the basaltic layer. — D. B. V.

- 185-358. Tvaltvadze, G[uri] K. Stroyeniye zemnoi kory v Gruzii po seysmicheskim dannym i postroyeniye sistem teoreticheskikh godografov [Crustal structure in Georgia according to seismic data and construction of a system of theoretical traveltime curves]: Tbilisi, Akad. Nauk Gruzin. SSR, 144 p., 1960.

The crust in the Georgian S.S.R. has been studied using earthquake and explosion seismology data. In the Borzhomi valley the first layer (sediments)

is 3.5-4.0 km thick, and the P- and S-wave velocities are 4.4 km/s and 2.6 km/s, respectively. The second layer (granitic) is 20 km thick, and the P- and S-wave velocities are 5.6 km/s and 3.2 km/s, respectively. The third layer (basalt) is 24 km thick, and the P- and S-wave velocities are 6.7 km/s and 4.0 km/s, respectively.

In the Tkibuli region the sediments are 7 km thick, and the P- and S-wave velocities are 4.3 km/s and 2.6 km/s, respectively. The granitic layer is about 17 km thick, and the P- and S-wave velocities are 5.6 km/s and 3.4 km/s, respectively. The thickness of the basaltic layer could not be determined, but the P- and S-wave velocities are 6.5 km/s and 3.9 km/s, respectively.

In the Caucasus the sedimentary layer is 10 km thick, and the P- and S-wave velocities are 4.5 km/s and 2.6 km/s, respectively. The average thickness of the granitic layer is 15 km, and the P- and S-wave velocities are 6.0 km/s and 3.4 km/s, respectively. The average thickness of the basaltic layer is 25 km, and the P- and S-wave velocities are 7.0 and 4.0 km/s, respectively. P- and S-wave velocities are 8.0 km/s and 4.7 km/s, respectively, for the surface of the mantle. — J. W. C.

- 185-359. Pronin, A. A. O glubinnoy tektonike i obrazovanii granitov Urala [On the deep structure and formation of the granites of the Urals (with English summary)]: Internat. Geol. Cong. 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 217-223, 1960.

Throughout its whole geologic history the folded belt of the Urals has been a mobile crustal zone. The sial underlying the Urals is heterogeneous in structure. In zones of Paleozoic subsidence it consists of a lower basaltic layer and an upper sedimentary layer, the latter including igneous intrusions and extrusions. In zones of uplift it consists of three layers: basaltic, granitic, and sedimentary. The Ural granites are of metasomatic origin, formed by granitization of ancient paragneisses and other metamorphic and sedimentary rocks. — D. B. V.

- 185-360. Shikhaliyev, E. Sh. K voprosu o glubinnom stroenii vpadiny Yuzhnogo Kaspiya i okruzhayushchikh oblastey [On the problem of the deep structure of the South Caspian depression and neighboring regions (with English summary)]: Internat. Geol. Cong., 21st Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 171-178, 1960.

The deep structure of the South Caspian depression and its environs is outlined on the basis of data from recent geophysical (particularly gravimetric) investigations. This depression is the eastward continuation of the Lower Kura basin. The basement structure, masked by Cenozoic deposits, is heterochronous and varies from place to place in a complicated way. The granitic layer pinches out toward the axial part of the South Caspian depression and is lacking under the Lower Kura basin; the crust there is oceanic in character, analogous to parts of the Mediterranean area, including the Black Sea. — D. B. V.

- 185-361. Veytsman, P. S., Gal'perin, Ye. I., Zverev, S. M., Kosminskaya, I. P., and Krakshina, R. M. Nekotoryye dannyye o stroenii zemnoy kory v perekhodnoy zone ot Aziatskogo kontinenta k Tikhomy okeanu [Some data on crustal structure in the transitional zone from the Asiatic continent to the Pacific Ocean (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 37-42, 1960.

This is a short version of the paper published in *Freiberger Forschungshefte C 81 Geophysik*, p. 150-159, 1960 (see *Geophys. Abs.* 184-431). — D.B.V.

- 185-362. Maeda, Y. Crustal structure in and near Shikoku district as deduced from forerunner analysis [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 25, no. 2, p. 35-44, 1960.

A study of waves of different periods and amplitudes in the forerunner group of earthquake waves is an effective means of determining crustal structures. The crustal structure in and near the Shikoku district was studied using Takagi's method and Matuzawa's standard crustal structure of two layers above the M-discontinuity with thickness and P-wave velocity of 20 km at 5.0 km/s and 30 km at 6.3 km/s and with a P-wave velocity below the M-discontinuity of 7.5 km/s. The thickness of Matuzawa's first layer and the depth of the M-discontinuity in the Shikoku district as deduced from the study are shown in figures. — V. S. N.

- 185-363. Talwani, Manik, Worzel, J. Lamar, and Ewing, Maurice. Gravity anomalies and crustal section across the Tonga Trench: *Jour. Geophys. Research*, v. 66, no. 4, p. 1265-1278, 1961.

The seismic structure determined by Raitt and others (see *Geophys. Abs.* 163-256) for the Tonga Trench was projected to one of the gravity profiles obtained in 1956 with the Vening Meinesz pendulum apparatus. The gravity anomaly profile computed on the basis of the seismic structure is in fair agreement with the observed profile, but the two profiles differ by about 100 mgal in the vicinity of the trench. Interposing a seismically "masked" layer under the trench and increasing the crustal thickness there to 23 km improves the fit.

A crustal thickness of 36 km is derived from gravity and seismic data for the Tonga-Kermadec Ridge. The disagreement between this value and one obtained by Officer (see *Geophys. Abs.* 162-232) from surface wave dispersion data might be explained by an abnormally low shear velocity in the crust underlying the ridge. — D. B. V.

- 185-364. Evison, F. F., Ingham, C. E., Orr, R. H., and LeFort, J. H. Thickness of the earth's crust in Antarctica and the surrounding oceans: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 289-306, 1960.

Love and Rayleigh waves from eight earthquakes recorded at Hallet Station, Scott Base, and Mirny have been analyzed, and the dispersion compared with that predicted by theory for simple crustal models. It is concluded that the crust in eastern Antarctica as a whole is continental with a thickness of about 35 km. In contrast, Marie Byrd Land has an average crustal thickness of about 25 km. The data do not extend to the rest of western Antarctica, nor has it been possible to study the important transition zone from the Ross Sea to the Weddell Sea. The average crustal thickness of 25 km in the western sector could be explained in a variety of ways. The concept of an archipelago of mountainous island chains is supported by recent seismic and gravity observations.

Love wave dispersion indicates that the thickness of the solid crust in the oceanic regions surrounding Antarctica ranges from about 5 to 10 km, the smaller values being associated with the deeper basins. It is shown that the determination of the thickness of the oceanic crust and of the unconsolidated bottom sediments from Rayleigh wave dispersion is in general subject to large uncertainties. — D. B. V.

- 185-365. Gaskell, T[homas] F. Drilling of deep bore-holes: *Adv. Sci.* v. 17, no. 70, p. 534-540, 1961.

Techniques of drilling deep boreholes are summarized briefly. The importance of selecting the technique most suitable for drilling to the M-discontinuity is emphasized because of the information to be gained from core recovery and measurement of rock properties in place by logging instruments. Such information will make it possible to determine whether the M-discontinuity is the result of a phase change caused by temperature and pressure effects or the result of a change in rock type that will be recognizable in the core. — V. S. N.

- 185-366. Wilson, Gilbert M. Project Mohole demonstrates deep water drilling techniques: *World Oil*, v. 152, no. 7, p. 84-90, 1961.

Six core holes have been drilled from the CUSS I drilling vessel in the Pacific Ocean. Five holes were in 3,140 feet of water and the deepest penetration was 1,043 feet. The sixth hole was in 11,700 feet of water; it passed through soft, gray-green clay of Miocene age, topped basalt at 560 feet, and was still in the basalt when it bottomed at 601 feet. Finding this basalt confirms earlier seismic surveys of the area. These tests demonstrate that depth of water need not be a barrier to oil exploration. — J. W. C.

- 185-367. Meinhold, Rudolf. Das "Mohole"-Projekt [The "Mohole" project]: *Zeitschr. Angew. Geologie*, v. 6, no. 4, p. 182-183, 1960.

This is a brief review of the "Mohole" project, particularly from the point of view of the drilling problems involved. — D. B. V.

- 185-368. Press, Frank. The earth's crust and upper mantle: *Science*, v. 133, no. 3463, p. 1455-1463, 1961.

The seismological and gravitational methods of exploring the outermost few hundred kilometers of the earth and the results obtained to date are described, and some unsolved problems and the methods of attacking them are discussed.

A complete physical explanation of the low-velocity layer has yet to be given. It is probably a result of temperature; rocks near their melting point can occur in this zone, which may be the source of the primary basaltic magma.

None of the measurements reported here settle the question of phase changes versus changes in composition as the reason for the Conrad and Mohorovičić discontinuities; it will probably be resolved only by drilling to the top of the mantle. — D. B. V.

- 185-369. Demenitskaya, R. M. Stroyeniye kristallicheskoy chasti obolochki Zemli po geofizicheskim dannym [Structure of the crystalline part of the earth's shell according to geophysical data (with English summary)]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 2, sec. 2, p. 20-36, 1960.

Structurally the earth's crystalline shell can be regarded as a whole, the crust and the underlying "hyperbasite" of the mantle being closely interrelated. A world map of crustal thickness, constructed from seismological data, shows the main morphologic features of the surface of the hyperbasite; its maximum uplifts are mainly in the southern hemisphere and maximum depressions in the northern hemisphere, with maximum ruggedness in the equatorial region. At 10 km depth the granite layer is predominant in the north-

ern hemisphere, and the basalt-hyperbasite layer in the southern. At 50 km the shell consists mainly of hyperbasite, with two basalt belts—one trending almost north-south in the western hemisphere and one trending almost east-west in the eastern hemisphere; two smaller areas of basalt correspond to the roots of the Abyssinian plateau and of the cordillera of eastern Australia. — D. B. V.

- 185-370. Magnitskiy, V. A. O sootnoshenii zemnoy kory s veshchestvom obolochki Zemli po geofizicheskim dannym [On the relations between the earth's crust and the matter of the earth's mantle according to geophysical data (with English summary)]: Internat. Geol. Cong., 21st, Copenhagen 1960, Doklady Sovet. Geologov, Problema 18, p. 32-38, 1960.

As heat flow is the same on continents and oceans, it is inferred that the principal blocks of oceanic and continental crust were formed in their present positions. The crust and peridotitic secondary mantle were derived from a primordial eclogitic mantle. With decreasing pressure and increasing temperature, minerals of the eclogite rocks changed into two kinds of compounds. Those with relatively low melting point and density migrated upward to form the crust, and those with higher melting point and density formed the peridotitic secondary mantle. Under the continents this separation has been rather complete; under the oceans the mantle retains an almost primordial composition. — D. B. V.

- 185-371. Jobert, Georges. Sur la densité interne du Globe [On the internal density of the globe (with French, English, Esperanto, and Russian summaries)]: Annales de Géophysique, v. 16, no. 3, p. 422-425, 1960.

A method used by Stieltjes (1914) for calculating the limits of densities in the earth's interior has been modified by assuming a discontinuous density within the earth. The method is found to lose much of its effectiveness when density discontinuities are taken into account, but it still gives within relatively narrow limits the values of density at the center of the earth, at the surface of the core, and at the base of the mantle, as well as the density contrast at the core boundary. Results obtained for two different values of density at the top of the mantle ($d=3.32$ and 3.67 g per cm^3) are tabulated. It is remarkable that the minimum density contrast of 4.68 g per cm^3 for $d=3.67$ is very close to Bullard's solution I value of 4.70 g per cm^3 . For $d=3.32$, the minimum density contrast at the core boundary is 2.74 g per cm^3 . — D. B. V.

- 185-372. Rikitake, Tsuneji. Geophysical evidence of the olivine-spinel transition hypothesis in the earth's mantle: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 423-431, 1959.

The difference in free energy between the substances constituting the upper and lower mantle, estimated on the assumption that an olivine-spinel transition occurs at a depth of 400 km in the earth, is approximately the same as that deduced by Ringwood (see Geophys. Abs. 173-241) from experimental results. Consideration of the effect of this transition on the electrical conductivity shows that the sharp increase of conductivity at depth as inferred from studies of geomagnetic variations seems to be justified by the transition hypothesis. — D. B. V.

- 185-373. Zharkov, V. N. Fizika yadra Zemli. Termodinamicheskiye svoystva I [The physics of the earth's core. Thermodynamic properties. I]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1417-1425, 1960.

The theory of the thermodynamics of the earth's core is developed in a way similar to that used by Zharkov for the earth's mantle (see Geophys. Abs. 181-319). The core of the earth is assumed to be homogeneous, having a sharp velocity increase of longitudinal seismic waves in the inner core due to differences in state. When the oscillation period is of the order of seconds the outer core behaves as a fluid and the inner core as a solid. The velocities of longitudinal seismic waves are assumed to be $v_{pe}^2 = (K/\rho)$ for the outer core and $v_{pe}^2 = \frac{K + (4\mu/3)}{\rho}$ for the inner core, K being the volume modulus of incompressibility, μ the shear modulus, and ρ the density. Using the Grüneisen parameter γ calculated from the Davydov formula (see Geophys. Abs. 169-194) and the Debye theory, and assuming the thermal pressure P_T in the Davydov' formula equal to zero, Zharkov arrives at the value of $\phi = K/\rho = Kx/\rho_0$ in terms of Davydov's constants K_1 , K_2 , and b . Having determined the shear modulus μ for the "effectively solid core," Zharkov has calculated and presented graphically as a function of depth: the variation of K , μ , and P (pressure) in the core of the earth; the variation of seismic velocities v_p and v_s in the "effectively solid" core; the variation of the Debye temperature θ_{Si} for the "silicate" model of the core and θ_{Fe} for the "iron" model, and the Grüneisen parameter γ ; the variation of thermal pressure P_T^{Si} and P_T^{Fe} for the "silicate" and "iron" core models respectively; and the variation of the derivative $(\partial p / \partial T)_{T_1}$ in the core of the earth. Formulas for the adiabatic temperatures and their gradients are obtained for the evaluation of the temperature variation in the inner core. — A. J. S.

- 185-374. Zharkov, V. N. Fizika yadra Zemli. Mekhanicheskiye svoystva i vyazkost', II. [Physics of the earth's core. Mechanical properties and viscosity, II]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1553-1562, 1960.

This is a continuation of Zharkov's previous paper on the earth's core (see Geophys. Abs. 185-373); problems related to viscosity are treated. Data on the passage of seismic waves of various periods through the earth's core are analyzed to determine whether Gutenberg's view is correct (see Geophys. Abs. 171-204, 175-53, -54) that a high gradient of viscosity in zone F causes a strong dispersion of longitudinal waves, or whether such a dispersion takes place according to Bullen's model wherein the dispersion occurs at the boundary of the solid inner core and the fluid outer core (see Geophys. Abs. 177-235). It was established by Gutenberg that the location of the seismic boundary of the inner core depends on the period (frequency) of the waves used in determination of the boundary. The observations that led to the discovery of the inner core were based mainly on waves of 1-10 second periods. Their behavior is not due to the existence of a real physical boundary but rather to the nature of the seismic wave propagation in the earth as a whole and to the properties of the seismographs. Zharkov considers that it is more plausible to assume that the dispersion of seismic waves of 10^{-6} second period takes place at the real physical boundary between the outer and the inner cores; therefore, the actual boundary that separates the fluid part from the crystalline part of the core may be situated considerably closer to the earth's surface. Consequently, the boundary of the inner core determined by seismologists is but a seismic boundary of the inner core and not necessarily a physical boundary. Two models of the earth's core are discussed: (1) The inner part of the core is in a solid polycrystalline state and at the fluid phase boundary has an effective viscosity coefficient of the order of 1 ps for deformations

$\epsilon \leq 10^{-5}$; and (2) the entire earth's core is in an amorphous state, its viscosity coefficient η decreasing exponentially from the center to the periphery; its seismic boundary is located in the region where the values of the nonrelaxing shear moduli μ and η are such as to satisfy the condition $2\pi\eta/\omega \ll 1$, t being the wave period. The result of this analysis indicates that the position of the seismic boundary for the higher frequencies ($t \sim 0.5$ sec) can be evaluated from the graph of relaxation time as a function of depth given in the paper. This boundary should be about 100 km farther away from the center than that for the waves of 1 second period. It is considered that the transition from the effectively solid part of the core should be less abrupt than proposed by Gutenberg, that lower period waves should be reflected from zones farther from the center of the earth than the higher period waves, and that the absorption of seismic waves in the boundary zone should be one order higher than in other seismically homogeneous zones of the core. The theory explains the velocity plateau and decrease of longitudinal wave velocity in the inner core. — A. J. S.

- 185-375. Al'tshuler, L. V., and Kormer, S. B. Ovnutrennem stoyenii Zemli [On the internal constitution of the earth]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 33-37, 1961.

Experiments on dynamic and isoentropic compressibility of metals, olivine, and pyrite provided data for an interpretation of the constitution of the external and internal cores of the earth. It was found by shock compression of olivine that its density becomes about 4.9 g per cm^3 under a pressure of 0.7 million atm, and 6.8 ± 0.2 g per cm^3 under 2.4 million atm, the temperature in the latter case reaching approximately 8,000°C. The correlation of pressure and density in the core of the earth with the dynamic adiabatic curves obtained in the laboratory for titanium, iron, molybdenum, and nickel shows that the density of the external core in the pressure range from 1.4 to 3.2 million atm is 1.5 g per cm^3 lower than that of iron. The experimental data on the compressibility of elements indicate that the core of the earth contains a substantial quantity of lighter substances besides iron and nickel. This supports the Knopoff and MacDonald conclusion that the earth's core is not pure iron (see Geophys. Abs. 181-322), and that its mean atomic number is 23. A comparison of sound velocity in the pressure range of 1.4-3.2 million atm with v_p of seismic waves in the external core indicates that the sound velocity is 1.2 km/sec higher than v_p in iron and nickel in the external core. Iron and nickel densities under the range of pressures 1.4-3.2 million atm (external core) do not agree with the Bullen's distribution of densities and differ from the density data of Molodenskiy at the mantle-core boundary (see Geophys. Abs. 165-224). A comparison of sound and seismic velocity curves in the inner core favors chemical homogeneity and solid state. A core composed of oxides or iron sulfides with a substantial admixture of free metals is tentatively proposed. — A. J. S.

- 185-376. Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 405-422, 1959.

A linearized treatment of the simultaneous equations of electromagnetism, hydrodynamics and heat transfer in a conducting fluid sphere is described. It turns out that a sort of thermo-magneto-hydrodynamic oscillation seems likely to occur through the couplings between magnetic fields, fluid motions and thermal fields. With some drastic simplifications, the eigen-period of the oscillation, which superposes on the steady state of the earth's dynamo, is estimated at 20 years. — Author's summary

- 185-377. Hahn-Weinheimer, P. Alterseinstufung von eklogitischen Gesteinen mit Hilfe des C^{12}/C^{13} -Isotopenverhältnisses von Graphit- und Karbonat-Kohlenstoff [Determination of the age relations of eclogitic rocks by means of the C^{12}/C^{13} isotope ratios of graphite- and carbonate-carbon]: Geol. Rundschau, v. 49, no. 1, p. 308-314, 1960.

Quantitative determinations of the stable carbon isotope ratios in graphite- and carbonate-carbon suggest that the eclogitic rocks of the Münchberger gneiss massif in Germany originally were slightly graphitic, dolomitic-marly schists, already metamorphosed in Precambrian time. Similarity of the C^{12}/C^{13} ratios in both types of carbon (more than 90.0) indicates syngenetic deposition of elementary carbon and carbonate. — D. B. V.

- 185-378. Park, R., and Dunning, H. N. Stable carbon isotope studies of crude oils and their porphyrin aggregates: Geochim. et Cosmochim. Acta, v. 22, no. 2-4, p. 99-105, 1961.

In order to elucidate the origin of the porphyrin aggregates in crude oils (which in turn is undoubtedly closely related to the origin of petroleum itself), the C^{13}/C^{12} ratios of petroleum and their porphyrin aggregates have been measured and compared with those of chemically similar substances of present-day organisms. The fact that the C^{13}/C^{12} ratios of all the relatively pure porphyrin aggregates are 4-5 permil greater than those in the crude oils suggests strongly that the former did not arise from the petroleum hydrocarbon by bacterial action, but must have been present during the formation and diagenesis of the oil. — D. B. V.

- 185-379. Cook, A. C. The carbon isotopic compositions of certain marine invertebrates and coals from the Australian Permian: Geochim. et Cosmochim. Acta, v. 22, no. 2-4, p. 289-290, 1961.

In a recent paper, Compston (see Geophys. Abs. 182-369) found no correlation of rank or chemical composition of coal with carbon isotopic composition. In view of the nature of the samples used, Compston's conclusions do not seem fully justified. Suggestions are made for disentangling the effects of rank and of maceral composition in order to eliminate some of the variables mentioned by Compston. — D. B. V.

- 185-380. Park, R., and Epstein, S[amuel]. Carbon isotope fractionation during photosynthesis: Geochim. et Cosmochim. Acta, v. 21, no. 1/2, p. 110-126, 1960.

It is desirable to understand the reasons for the isotopic fractionation in photosynthesis that favors the fixation of C^{12} into plants, because such knowledge should contribute to elucidation of the CO_2 fixation process itself and at the same time provide information pertinent to the interpretation of the C^{13}/C^{12} ratios of fossil carbon deposits. This paper described a series of controlled experiments designed to throw light on the problem.

Experiments on the extraction of "dissolved CO_2 " and on the enzymic fixation of carbon dioxide suggest that the major fractionation of carbon isotopes in the photosynthetic fixation of atmospheric carbon dioxide is due to two steps, the first involving preferential uptake of C^{12} from the atmosphere and the second the preferential conversion of C^{12} -rich "dissolved CO_2 " to phosphoglyceric acid, the first product of photosynthesis. Subsequent metabolism of photosynthetic products is also accompanied by isotope fractionation, but these fractionations affect the isotopic composition of only a few minor constituents of the plant as a whole.

This two-step model explains the difference between the C^{13}/C^{12} ratio of atmospheric CO_2 and plants; the variation of the C^{13}/C^{12} ratio in naturally-occurring plants; the nature of the variation of the C^{13}/C^{12} ratio of respired CO_2 , particularly during the beginning of the dark period; the C^{13}/C^{12} ratio of CO_2 extractable by acid from the plant; the C^{13}/C^{12} ratio difference between land and marine plants; the C^{13}/C^{12} ratio of the calcareous skeleton of algae; and the difference in the C^{13}/C^{12} ratio between lichens and higher plants. — D. B. V.

- 185-381. Pandow, M., MacKay, C., and Wolfgang, R. The reaction of atomic carbon with oxygen: significance for the natural radiocarbon cycle: *Jour. Inorg. Nucl. Chemistry*, v. 14, no. 3/4, p. 153-158, 1960.

The nuclear reaction responsible for production of natural radiocarbon in the upper atmosphere can be duplicated in an atomic reactor. When C^{14} atoms so produced are reacted with N_2-O_2 mixtures under a variety of conditions and the results corrected for complicating radiation-induced effects, it is found that 90-100 percent of the C^{14} is in carbon monoxide. Previously it had been assumed that $C^{14}O_2$ must be the product. As C^{14} in CO cannot be utilized in photosynthesis, possible mechanisms for converting CO into forms suitable for entrance into the biosphere are reviewed. The relatively long mean life of atmospheric CO leads to the prediction that the specific activity of natural CO may be greater than that of atmospheric CO_2 , and therefore greater than that of biospheric CO_2 . — D. B. V.

- 185-382. Bolin, Bert. On the exchange of carbon dioxide between the atmosphere and the sea: *Tellus*, v. 12, no. 3, p. 274-281, 1960.

The physical and chemical processes responsible for exchange of carbon dioxide between the atmosphere and the sea are analyzed. It is shown that the rate of transfer is considerably decreased due to the finite rate of hydration of CO_2 in water. This is the case both for a smooth water surface where molecular diffusion plays a role in the first few hundredths of a millimeter as well as for rough sea where turbulence extends all the way to the surface. A general agreement is found between the transfer rate deduced in this way and the rate of exchange estimated on the basis of the C^{14}/C^{12} ratio in the atmosphere and the sea. — Author's abstract

- 185-383. Bien, G. S., Rakestraw, N. W., and Suess, H[ans] E. Radiocarbon content in Pacific Ocean water: *Tellus*, v. 12, no. 4, p. 436-443, 1960.

Results of C^{14} determinations on surface water from the Pacific Ocean are in agreement with those reported by Rafter and Fergusson (see *Geophys. Abs.* 171-215, 172-149). However, abnormal concentrations seem to exist locally for which no oceanographic explanation can be given. Data are still insufficient to permit conclusions concerning the effect of atomic bombs.

Samples from a constant depth of about 3,500 m show a decrease in C^{14} content from south to north; this may be attributed to radioactive decay of C^{14} during migration. From this, the northward component of the rate of water movement is calculated to be about 0.06 cm per sec. C^{13} determinations, made in order to correct the C^{14} values for fractionation effects, were remarkably consistent. — D. B. V.

- 185-384. Keeling, Charles D. The concentration and isotopic abundances of carbon dioxide in the atmosphere: *Tellus*, v. 12, no. 2, p. 200-203, 1960; abridged version in *Am. Geophys. Union Trans.*, v. 41, no. 3, p. 512-515, 1960 (*Internat. Geophys. Year Bull. No. 38*).

A systematic seasonal and latitudinal variation in the concentration and isotopic abundance of atmospheric carbon dioxide has been found in the northern hemisphere. In Antarctica there is a small but persistent increase in concentration. The activity of land plants in the northern hemisphere is suggested in explanation of the seasonal variation. The rate of increase at the South Pole is nearly that to be expected from combustion of fossil fuel if no removal from the atmosphere takes place; this suggests that the oceans have had no effect in reducing the annual increase resulting from combustion of fossil fuel. However, since the seasonal variation in the northern hemisphere is several times larger than the annual increase, it is as reasonable to suppose that a small change in the factors producing this seasonal variation may also have produced an annual change counteracting an oceanic effect. — D. B. V.

- 185-385. Schaeffer, O[liver] A., Thompson, S. O., and Lark, N. L. Chlorine-36 radioactivity in rain: *Jour. Geophys. Research*, v. 65, no. 12, p. 4013-4016, 1960.

Chlorine-36 in the atmosphere is an interesting isotope for study of geological problems as well as for understanding the hazards of nuclear fallout, as it has a relatively long half life (308,000 yr) and is very soluble in water. Relatively high levels of Cl^{36} activity have been found in rain, several orders of magnitude above the level to be expected from cosmic-ray production. It is almost surely the result of neutron irradiation of sea water by nuclear explosions.

The Cl^{36} has been added to the atmosphere in a relatively short time. If bomb testing is not resumed it will gradually leave the stratosphere and enter the ground water and finally the sea, where it will eventually be lost because of the large amount of stable chloride in the sea. It has already been detected in ground waters; by careful sampling it should be possible to study the processes involved in the storage of water underground. — D. B. V.

- Ehmann, William D., and Huizenga, John R. A search for long-lived Ca^{50} and Cr^{56} . See *Geophys. Abs.* 185-26.

- 185-386. Kokubu, Nobuhide, Mayeda, T[oshiko], and Urey, H[arold] C. Deuterium content of minerals, rocks, and liquid inclusion from rocks: *Geochim. et Cosmochim. Acta*, v. 21, no. 3/4, p. 247-256, 1961.

Samples of minerals, rocks, and liquid inclusions from rocks have been analyzed for water and deuterium content of the water. As juvenile water in samples from Hawaii and Japan contains less deuterium than the average surface water of the earth, it is concluded that juvenile water contains less deuterium than the oceans.

Possible explanations for this discrepancy are (1) protium equivalent to about 4 percent of the oceans has escaped from the earth; or (2) at the time of its formation the earth acquired surface water of high deuterium content and deeply buried water of low deuterium content. It is pointed out that certain carbonaceous chondrites contain the highest deuterium concentrations ever found in nature, whereas others of this group contain water of about average terrestrial composition. — D. B. V.

- 185-387. Friedman, Irving, Schoen, Beatrice, and Harris, Joseph. The deuterium concentration in Arctic sea ice: *Jour. Geophys. Research*, v. 66, no. 6, p. 1861-1864, 1961.

Analysis of the relation of deuterium content to depth in cores of sea ice collected near Ice Island and in Drifting Station Alpha demonstrates the existence of a relatively thin layer of deuterium-depleted water on parts of the surface of the Arctic Ocean during the summer. This layer is believed to form by the melting of snow, which is known to be highly depleted in deuterium, and the mixing of this melt water with sea water. Owing to vertical mixing this layer may blend with the deep water and will often disappear before the Arctic winter begins. However, in some cases a deuterium-depleted layer apparently persists until winter and becomes incorporated into the bottom of the ice that has persisted over the summer. — D. B. V.

- 185-388. Botter, René, Lorius, Claude, and Nief, Guy. Sur la datation des couches de névé dans l'Antarctique [On the dating of névé layers in the Antarctic]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 3, p. 437-439, 1961.

The relation established previously between deuterium content and temperature of formation of precipitations (see *Geophys. Abs.* 184-448) is used to date névé layers in the Antarctic ice cap; the hydrogen isotopic concentrations are correlated with observed seasonal changes in troposphere conditions in 1957-59. This application is somewhat limited because there is some irregularity in the meteorological phenomena; however, the results are no less valid than those based on stratigraphic profiles, and provide an indispensable complement to the latter. — D. B. V.

- 185-389. Horibe, Yoshio, and Kobayakawa, Mituko. Deuterium abundance of natural waters: *Geochim. et Cosmochim. Acta*, v. 20, no. 3/4, p. 273-283, 1960.

The deuterium abundance in natural waters from various sources has been determined by means of a deuterium mass spectrometer. The variation of deuterium contents of tap water at Tokyo and Osaka, Japan, during the last two years was within ± 1 percent, and no seasonal variation could be detected. Marine waters of the western Pacific have almost the same deuterium content as those of the Pacific Coast of the United States. Marine waters at various depths in the Antarctic Ocean show a relatively large variation of deuterium content from +0.84 to -1.16 percent of the standard mean ocean water (SMOW) scale whereas samples of the Black Current of the Pacific Ocean show little variation. It was found that the deuterium content of spring water suggests the origin of springs in some cases. Differences in the deuterium abundance in ground water in different parts of Japan suggest that the ground water is not necessarily of the same origin. — D. B. V.

- 185-390. Craig, Harmon. Isotopic variation in meteoric waters: *Science*, v. 133, no. 3465, p. 1702-1703, 1961.

The relationship between deuterium and oxygen-18 concentrations in natural meteoric waters from many parts of the world has been determined with a mass spectrometer. The isotopic enrichments, relative to sea water, display a linear correlation over the entire range for waters which have not undergone excessive evaporation. — Author's abstract

- 185-391. Brown, R. B. Hydrology of tritium in the Ottawa Valley: *Geochim. et Cosmochim. Acta*, v. 21, no. 3-4, p. 199-216, 1961.

Tritium deposition in rainwater at Ottawa, Canada, is reported for the years 1953-59. Correlation with the tritium content of drainage water in the district has allowed study of the hydrodynamics of the water system. A turnover rate constant of 0.27 yr^{-1} has been found for a storage reservoir of 2.1 m. The fraction of fresh precipitation in re-evaporated water has been estimated as 0.55 ± 0.1 . A deposition rate of cosmic tritium of 1.3 ± 0.1 atoms per cm^3 per sec has been obtained from early data. — Author's abstract

- 185-392. Ashizawa, F. T., and Kuroda, [Paul] K. The occurrence of the short-lived iodine isotopes in natural and in depleted uranium salts: *Jour. Inorg. Nucl. Chemistry*, v. 5, no. 1, p. 12-22, 1958.

The occurrence of the short-lived iodine isotopes in nonirradiated uranium salts has been established. The equilibrium ratios of the short-lived iodine isotopes to U^{238} in depleted uranium agree within experimental error with those in natural uranium. The ratios, expressed in terms of 10^{-4} disintegrations per sec per g U^{238} , are: I^{131} , 0.3 ± 0.1 ; I^{132} , 2.5 ± 0.3 ; I^{133} , 1.0 ± 0.2 ; I^{134} , 3.6 ± 0.4 ; and I^{135} , 3.5 ± 0.4 . Using Serge's value for the spontaneous fission half life of U^{238} of $(8.04 \pm 0.3) \times 10^{15}$ yr, the corresponding yields of iodine isotopes are: I^{131} , 0.4 ± 0.1 ; I^{132} , 3.6 ± 0.4 ; I^{133} , 1.5 ± 0.3 ; I^{134} , 5.2 ± 0.5 ; and I^{135} , 5.1 ± 0.5 percent. — D. B. V.

- Goles, Gordon G., and Anders, Edward. Iodine content of meteorites and their I^{129} - Xe^{129} ages. See *Geophys. Abs.* 185-95.

- 185-393. Russell, R[ichard] D., and Farquhar, R. M. Lead isotopes in geology: New York, Interscience Publishers Inc., 243 p., 1960.

The interpretation of lead isotope abundances as applied to geologic studies is discussed in eight chapters as follows: introduction, measurement of lead isotope ratios, age of the earth, dating galenas by means of their isotopic constitutions, anomalous leads, case histories, extensions of the Holmes-Houtermans model, and lead-uranium-thorium methods of age determination. Several hundred isotopic analyses of common leads are listed in appendices 1-12. Some of these have been obtained from the literature while others represent Toronto analyses, many of which are published here for the first time. A reference list contains 106 items. — V. S. N.

- 185-394. Nielsen, Helms. Zur lagerstättengenetischen Deutung der Isotopenverhältnisse am Blei und Schwefel [The metallogenetic significance of the isotope ratios in lead and sulfur]: *Geol. Rundschau*, v. 49, no. 1, p. 289-308, 1960.

The metallogenetic significance of the lead isotope ratios lies mainly in the anomalies with respect to the Holmes-Houtermans model lead; the absolute age is used only as a control or as a tie with the geologic time scale. The cause of the anomalies is discussed. In the lighter elements, including sulfur, isotope fractionation takes place in the course of geochemical processes; exogene circulation, for example, can be deduced from the isotope ratios. Most work in this connection has been done on galena sulfur. The techniques and results of investigations on some West Harz lead sulfide ores are presented. — D. B. V.

Marshall, Royal R., and Hess, David C. Lead from some stone meteorites. See *Geophys. Abs.* 185-86.

Hess, D[avid] C., and Marshall, R[oyal] R. The isotopic compositions and concentrations of lead in some chondritic stone meteorites. See *Geophys. Abs.* 185-87.

Sheline, R. K., and Hooper, J. E. Probable existence of radioactive manganese-53 in iron meteorites. See *Geophys. Abs.* 185-83.

Honda, M[asatake], Shedlovsky, J. P., and Arnold, J[ames] R. Radioactive species produced by cosmic rays in iron meteorites. See *Geophys. Abs.* 185-82.

185-395. Engel, A. E. J., Clayton, R[obert] N., and Epstein, S[amuel]. Variations in the isotopic composition of oxygen in the Leadville limestone (Mississippian) of Colorado as a guide to the location and origin of its mineral deposits: *Internat. Geol. Cong.* 20th, Mexico 1956, Symposium de Exploración Geoquímica, v. 1, p. 3-20, 1958.

Analyses of the oxygen isotopes O^{18} and O^{16} in unaltered and in hydrothermally altered limestone, dolomite, and quartz at Leadville, Colo., show that the highest $\delta O^{18}/O^{16}$ values are obtained from bedded calcite, dolomite, and chert that have not been recrystallized by hydrothermal water (unaltered beds), whereas the lowest $\delta O^{18}/O^{16}$ values, indicative of higher temperature, are from the hydrothermal calcite, dolomite, and quartz closest to ore. These variations in the oxygen isotope composition are consistent with independent geological evidence on the origin of the rock.

In the dolomite halo associated with the sulfide mineralization, variations in structure, texture, and concentration of elements and minerals are seemingly unsystematic with respect to ore; hence, the variations in oxygen isotopes may represent a useful guide to ore. — D. B. V.

185-396. Degens, Egon T. Stabile Isotope in ihren Beziehungen zur Zeit [Stable isotopes in their relations to time]: *Geol. Rundschau*, v. 49, no. 1, p. 277-278, 1960.

The use of the stable oxygen isotopes in determining the temperature of formation of ice caps or carbonate sediments is discussed briefly, and the significance of stable sulfur isotopes in ore genesis studies is mentioned. — D. B. V.

185-397. Emiliani, C[esare], Mayeda, T[oshiko], and Selli, R. Paleotemperature analysis of the Plio-Pleistocene section at Le Castella, Calabria, southern Italy: *Geol. Soc. America Bull.*, v. 72, no. 5, p. 679-688, 1961.

A section 167.80 m thick, including the paleontologically defined Plio-Pleistocene boundary, was logged and sampled at close stratigraphic intervals. Oxygen isotope analyses of different species of pelagic and benthonic foraminifera and of shell fragments of benthonic mollusks have revealed numerous temperature oscillations. A major shift of temperature ranges toward lower values from late Pliocene to late Pleistocene is indicated. No major temperature change seems to have occurred across the Plio-Pleistocene boundary; an areal extension of the ice somewhat greater than at present is suggested.

Major continental glaciations may not have started until later than early Pleistocene, because none of the temperature minimums in the Le Castella section appear to have been as low as values obtained for the glacial ages in the eastern Mediterranean. — D. B. V.

- 185-398. Bowen, Robert. Paleotemperature analyses of Mesozoic Belemnoidea from Australia and New Guinea: *Geol. Soc. America Bull.*, v. 72, no. 5, p. 769-774, 1961.

Paleotemperature analyses were carried out by means of oxygen isotope measurements on more than 60 Belemnoidea obtained from Mesozoic strata in Western and South Australia and New Guinea. One set of data records mean rostral temperatures, and another derived by analyzing successive increments of powdered carbonate from the rostra shows the variations of temperature during ontogenies. The latter probably represent, and in this event would confirm, seasonal changes during the Mesozoic. The former demonstrate a cooling from the Jurassic into the Cretaceous and are consistent with the extension of the Albian and Coniacian-Santonian climatic maximums, previously demonstrated in Europe, into the Australian area. The Cretaceous readings dispose of the idea of an ice age in South Australia at that time. It appears that the Belemnoidea were eurythermal through most of their evolutionary history. The paleotemperature results are in accord with a possibly large migration of Australia during the Mesozoic. — D. B. V.

Sharp, Robert P., Epstein, Samuel, and Vidziunas, Irene. Oxygen-isotope ratios in the Blue Glacier, Olympic Mountains, Washington. See *Geophys. Abs.* 185-297.

Hess, David C., Marshall, Royal R., and Urey, Harold C. Surface ionization of silver; silver in meteorites. See *Geophys. Abs.* 185-89.

- 185-399. Nilsson, Ragnar; Olsson, Ingrid; Berggren, Adolf; and Siegbahn, Kai. S^{35} and Be^7 contents in rain and snow: *Arkiv Geofysik*, v. 3, no. 2-3, p. 111-122, 1961.

The average S^{35} concentrations in some Swedish rain and snow samples were found to be 230 and 175 atoms per cm^3 and the average Be^7 concentrations to be 1,500 and 3,000 atoms per cm^3 at Uppsala and Abisko, respectively.

Calculations of the production rate of Be^7 , made for different locations where measurements of Be^7 have been carried out, agree at least qualitatively with the experimental data. The deposition rate appears to be influenced by latitudinal and seasonal variations in tropopause height. — D. B. V.

Picciotto, Edgard E. Geochemistry of the radioactive elements in the ocean and chronology of the ocean sediments. See *Geophys. Abs.* 185-11.

Goles, Gordon G., and Anders, Edward. The record in the meteorites. 6. On the chronology of the early solar system. See *Geophys. Abs.* 185-91.

MAGNETIC FIELD OF THE EARTH

- 185-400. Chatterjee, J. S. Magnetic disturbances and the earth's magnetic field: *Jour. Geophys. Research*, v. 66, no. 5, p. 1535-1546, 1961.

An attempt is made to explain the origin of the observed magnetic field of the earth as being due to a current system circulating in the core, the current system in its turn being maintained by world-wide magnetic disturbances.

The mantle behaves as a semiconductor, and the conduction electron density is given by the Boltzmann distribution law. The conductivity changes steeply along the radial direction, and a "potential hill" is produced in the radial direction. Owing to interaction of the induced current with the steady magnetic field, a Hall potential is developed; this modifies the existing "potential hill," and hence the conductivity becomes to some extent dependent on the induced current vector. The consequent nonlinearity rectifies the induced current, and a net amount of unidirectional current aiding the existing magnetic field is left over at the end of the disturbance. This gradually penetrates down to the core and has a decay time of the order of a million years. The net unidirectional current then grows through successive disturbances. It is shown that, for reasonable values of conductivity, temperature, and electron mobility, the magnetic disturbances maintain sufficiently large current in the core so that the earth's magnetism can be explained as entirely due to the magnetic disturbances. — Author's abstract

- 185-401. Cagniard, Louis. Panorama du magnétisme terrestre [Panorama of terrestrial magnetism]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 1, p. 148-150, 1961.

The globe accumulates, in the form of more or less persistent induced currents, the vestiges of variations of its rotational velocity. Terrestrial magnetism, constantly evolving, represents essentially the sum of the more or less ancient, more or less dulled reminders that the earth has been able to preserve the past rotational variations. — Author's abstract, D. B. V.

- 185-402. Lucke, Otto. Die dynamischen Gleichungen des Plasmas in der Magnetosphäre [The dynamic equations of the plasma in the magnetosphere (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 3, p. 105-137, 1960.

The assumptions necessary for describing large-scale movements of plasma of the magnetosphere by dynamic equations are given. For stationary conditions these equations lead to magnetic ring-currents which are intensified in the main phase of magnetic storms but are also present otherwise. They are most strongly developed in regions in which the impressed magnetic field is most deformed by the diamagnetism of the plasma. In these regions a maximum value is reached for the density of the electrically charged particles, whose magnetic moment, caused by transverse movement around the magnetic lines of force, can be regarded as an adiabatic invariant. The transverse kinetic energy density is then $3/2$ of the energy density of the magnetic field. The maximum particle densities are calculated; they are in plausible agreement with the measured values. The results show that the theory of magnetic storms needs further development. — Author's German abstract, D. B. V.

- 185-403. Forbush, S. E. Theoretical and statistical geophysics: Carnegie Inst. Washington Year Book 59, p. 222-226, 1960; reprinted in Carnegie Inst. Washington Dept. Terrestrial Magnetism Ann. Rept. of Director for 1959-60, 1960.

Investigation of the equatorial electrojet was continued during the year (see Geophys. Abs. 184-465). Assuming a height of 100 km (106 km in the Pacific) for the eastward primary electrojet current near midday, the width of the primary current band is found to be about 660 km centered above the magnetic dip equator. A new technique was found for the separation of the observed field of the electrojet (near midday) into components of origin external and internal to the earth, together with separation of jet effects from normal effects.

The induced (internal) field is compatible with that from the image of the jet band current flowing westward at a depth of about 600 km; this is in accord with the concept that the earth's crust is essentially nonconducting to a depth of 250 km and perfectly conducting below that depth. No electrojet effects were found at night, and there is no evidence for electrojet effects on the storm time variation (Dst). Studies were conducted also to ascertain whether some of the observed asymmetry in the diurnal variation of the vertical field north and south from the center of the electrojet may arise from deviations from uniform subterranean conductivity. Fields were examined at five stations in the Peruvian net from a few night-time sudden commencements. An electrojet effect in the lunar variation is also indicated. Cosmic-ray investigations are reported briefly. — V. S. N.

- 185-404. Sakurai, Kunitomo. The cosmic ray equator and geomagnetism: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 12, no. 1, p. 13-20, 1960.

Deviation of the cosmic ray equator from the geomagnetic dipole equator is found to be negligible, even if a magnetic cavity exists around the outer atmosphere. Taking this factor into account, the origin of the cosmic ray equator is considered. It is found to be produced by the higher harmonic components combined with the dipole component of geomagnetism; therefore, it originates in the interior of the earth. As it is impossible that local magnetic anomalies in the crust can be the cause, it is suggested that the origin lies in the eccentric dipoles in the outer part of the core that contribute to geomagnetic secular variation. — D. B. V.

- 185-405. Whitham, Kenneth]. Measurement of the geomagnetic elements, in Methods and techniques in geophysics: London Interscience Publishers, Ltd., p. 104-167, 1959; reprinted in Dominion Observatory Ottawa Contr., v. 3, no. 30, 1959; also New York Interscience Publishers, Ltd., p. 104-167, 1960.

Following a brief description of the geomagnetic field and of absolute and relative magnetic measurements, magnitude of spatial and time variations, and limitations in magnetic measurements, the various methods of measurement of the geomagnetic elements are discussed in detail—torque, induction, saturable-core, Hall effect, magnetostriction, and proton-precession methods and methods using the deflection of free electrons in a magnetic field. The saturable-core and proton-precession methods are the most important developments in the last decade and have been developed rapidly and exploited fully in the study of spatial and time variations from a moving support. Although the use of electronic methods could be increased, good results with a sensitivity adequate for most purposes can be obtained using the classical methods, which make fewer demands on the technical competence of the operators and, thus, are important at small and isolated observatories. — V. S. N.

- 185-406. Whitham, Kenneth]. National report for Canada—Geomagnetism: Dominion Observatory Ottawa Pubs., v. 24, no. 4, p. 87-98, 1960.

A compilation of geomagnetic activity undertaken by university departments and government institutions in Canada since 1957 is presented. The following activities are summarized briefly: geomagnetic surveys; magnetic charts and maps; magnetic observations and variation stations; developments in magnetic instruments; aeromagnetic interpretation and correlation studies; paleomagnetic and magnetic rock-property studies; magnetotelluric and telluric current

studies; research into the main geomagnetic field and its secular variation; studies of magnetic field variations; and research into the E. M. method of prospecting. A bibliography of published results and of forthcoming publications is included. — V. S. N.

- 185-407. Haáz, Il[stván] B[éla] L'effet de la température dans les mesures au BMZ [The effect of temperature on BMZ measurements (with English, French, German, and Russian summaries)]: Acad. Sci. Hungaricae Acta Tech., v. 30, no. 3-4, p. 463-466, 1960.

In measurements with the BMZ magnetometer the temperature coefficient is a function of the Z-value, which is obtained only at the end of the calculation. The temperature correction may be computed by means of a coefficient belonging to the uncorrected Z-value, but the result may be corrected by a small value (ζ). A formula is given for this correction and some values of ζ obtained with three different instruments are tabulated. (See also Geophys. Abs. 171-247.) — D. B. V.

- 185-408. Orlov, V. P. Mirovaya karta magnitnykh meridianov na epokhu 1955 g [World map of magnetic meridians in the epoch 1955]: Akad. Nauk SSSR, Izv. Ser. Geofiz., no. 1, p. 104-106, 1961.

A world map of magnetic meridians for epoch 1955 has been published. It consists of two sheets: Northern Hemisphere and Southern Hemisphere. These are reproduced here at a reduced scale. A world chart of the residual magnetic field Z is also given. — J. W. C.

- 185-409. Tárczy-Hornoch, Antal. Über die Berechnung der magnetischen Deklination für einen Ort aus der gleichzeitigen magnetischen Deklination einer Referenzstation [On the calculation of the magnetic declination for a place from the contemporaneous declination of a reference station (with English summary)]: Gerlands Beitr. Geophysik, v. 69, no. 6, p. 321-327, 1960.

For the determination of magnetic declination of a territory, best-osculating mathematical planes are calculated for different epochs. The declinations corresponding to these planes are the normal declinations, which can be computed by interpolation for moments between and outside the epochs; the deviations from them represent the so-called local disturbances at individual places. The calculation of normal declinations by extrapolation is inexact and can be performed only for a limited period. The local disturbances, which are necessary for calculation of true declination, are assumed to be constant over a long period of time.

As these local disturbances depend on the osculating planes chosen and on the number and distribution of points included in the adjustment, a point may have different local disturbances even at the same moment. At different moments, different local disturbances are usually obtained, even with similar osculating planes and with the same number and distribution of observation points. Then interpolations can be made between the local disturbances at the same place at given moments. — Author's German summary, D. B. V.

- 185-410. Gouin, P. Magnetic activity at Addis Ababa from January to June 1958: Addis Ababa Univ. Coll., Geophys. Observatory Bull., v. 1, no. 1, p. 5-43, 1959.

The establishment of a geomagnetic observatory at Addis Ababa, Ethiopia was recommended because of its position practically on the magnetic equator. Operation began in January 1958. The station and instruments are described. Daily observations were made of the effects of singularity associated with the magnetic equator. One such effect is the enhancement of the H diurnal variation at these latitudes under the influence of the electro-jet current. There is also a high amplitude in the background activity, and the lunar effect is very large. During the observation period the electro-jet shifted north-south between 90 and 30 km south of Addis Ababa. — J. W. C.

- 185-411. Láncoz, Pál. A földmágneses tér hatóras periódusú változásáról [The six-hour periodic variations of the geomagnetic field (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 209-217, 1960.

The diurnal course of the geomagnetic X, Y, and Z components as recorded at the Budapest and Niemeck observatories since 1950 has been compared with theoretical curves in order to determine which components best reveal the features of the short-period variations. The amplitude of the 6-hr oscillation is greatest in the Y component. — D. B. V.

- 185-412. Fel'dshtein, Ya. I. The Dickson Island and Cape Cheliuskin Q-indices of magnetic activity: Canada Defense Research Board Directorate of Sci. Inf. Services, T 347 R, 7 p., 1961; translated from *Vozmuscheniya Elektromagnitnogo Polia Zemli*: Moscow, Akad. Nauk SSSR, 1960.

Data from magnetograms recorded at Dickson Island and Cape Chelyuskin from July 1956 to July 1957 are used in a study of the behavior of the new index of magnetic activity and for a comparison of results with those obtained with the old indexes. In deriving the Q-index, only the variations of the horizontal elements of the geomagnetic field, the declination D and the horizontal component H, are used. Results are illustrated in tables and graphs. — V.S.N.

- 185-413. Kakioka Magnetic Observatory. Report of the geomagnetic and geoelectric observations during the International Geophysical Year, 1957-58: Kakioka, Japan, Kakioka Magnetic Observatory, 487 p., 1960.

The results of observations during the International Geophysical Year of rapid variations in the geomagnetic field and earth currents and of principal geomagnetic storms as carried out by the Kakioka Magnetic Observatory and its two branch magnetic observatories at Memambetsu and Kanoya, Japan, are reported. Instruments and methods of observation are briefly discussed. Observations are given in tables, and some examples of rapid-run magnetograms, induction magnetograms, and rapid-run tellurigrams are reproduced. — V. S. N.

- 185-414. Parkinson, W. D., and Curedale, R. G. Isomagnetic maps of Australia for the epoch 1957.5. Pt. 1—Eastern Australia: Australia Bur. Mineral Resources, Geology and Geophysics Rept., no. 55, 13 p., 1960.

Isomagnetic maps of Queensland, New South Wales, Victoria, and Tasmania showing five magnetic elements reduced to epoch 1957.5 are presented. The maps are based on results of regional magnetic observations made since 1910;

much of the data have been obtained since 1952. Data from the reoccupation of stations have been used to revise the older results and to estimate the present rate of change of the magnetic field. The estimated rate of change is shown on each map. — V. S. N.

- 185-415. New Zealand Department of Science and Industrial Research. International Geophysical Year Ionospheric data, Scott Base 1957-58, Cape Hallet 1957-58: New Zealand Dept. Sci. Indus. Research (Geophys. Div.), Christchurch Geophys. Observatory, 450 p., 1960.

This volume presents ionospheric data in tables for Scott Base and Cape Hallet, Antarctica, for the International Geophysical Year period, July 1, 1957-December 31, 1958. Frequency plots for regular and special world days will be published in a separate volume. — V. S. N.

- 185-416. Pinn, J. D. Field magnetic observations in Antarctica: Australia Bur. Mineral Resources, Geology and Geophysics Rept., no. 51, 7 p., 1960.

The results of magnetic observations at field stations in the Antarctic since 1954 are presented in tables. No analysis is made of the data. Observation points, shown on a map, are along the coast of the Australian Antarctic Territory and along two traverses extending about 350 miles south of Mawson. — V. S. N.

- 185-417. Ostenso, Ned A., and Bentley, Charles R. Observed magnetic declinations in West Antarctica: Jour. Geophys. Research, v. 66, no. 4, p. 1301-1302, 1961.

Declination observations were made at intervals of about 30-36 nautical miles on 6 oversnow traverses and at each of the 7 stations occupied by an airborne traverse in West Antarctica. The locations of all the observation sites are plotted on a map, along with isogonic lines contoured from these data at 10° intervals and isogonic lines plotted on H. O. map 1706S (1960). Agreement between observed and computed declination is remarkably good. Such discrepancy as does exist may be due either to the fact that the observations were made over a period of 3 yr, during which some secular variation would occur, and (or) to the fact that magnetic susceptibility is higher than normal in the western part of West Antarctica. — D. B. V.

- 185-418. Cagniard, Louis. La variation magnétique seculaire interpretée comme un "effet Rowland," accompagné de phénomènes d'induction électromagnétique [Secular magnetic variation interpreted as a "Rowland effect" accompanied by electromagnetic induction phenomena]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 19, p. 2053-2055, 1960.

The Rowland effect has never been invoked to explain secular magnetic variation because it generates a field that is proportional to the rotational velocity, a phenomenon which does not obtain. Furthermore, if very small fluctuations in rotation can cause magnetic variations of several hundred gammas, as recently suggested (see Geophys. Abs. 184-464), it is implied that the magnetic field itself should be of the order of billions of oersteds.

The Rowland effect could operate and still be compatible with the observations if it is assumed that certain parts of the globe are highly conducting. In a regime of uniform rotation, the positive and negative charges give rise to

enormous Rowland fields, but these will almost cancel out if the charges are situated in a "double layer" at the boundary between the core and mantle. When rotation varies, this compensation ceases; and if the conductivity of the interlayer is high enough, intense induced currents will flow there. Such an electromagnetic perturbation would require several centuries to be manifested outside the double layer. Calculations show that this effect is compatible with empirical data if the conductivity of the mantle is of the order of that of the electrolytes. — D. B. V.

Rikitake, Tsuneji. Thermo-magneto-hydrodynamic oscillations in the earth's core. See *Geophys. Abs.* 185-376.

- 185-419. Jacobs, J. A., and Sinno, K. World-wide characteristics of geomagnetic micropulsations: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 333-353, 1960.

Geomagnetic micropulsations recorded by rapid-run magnetographs during the International Geophysical Year at 17 widely distributed observatories are analyzed. A number of well-defined cases (14 Pt's and 3 Pc's) are investigated in detail. Diurnal and world-wide characteristics are derived, and the equivalent overhead current systems that may give rise to the micropulsations are constructed.

Pt's can be divided into two groups: Pt⁻, associated with a negative bay in the auroral zone, and Pt⁺, associated with either a positive bay or no bay in the auroral zone. Both classes have more or less coherent, synchronous wave forms over a wide area; that is, they have the same period at different stations, where they are either nearly in or out of phase. Pc's are found to consist of two different wave bands, both occurring during the daylight hours. The first band contains shorter period Pc's (15-30 sec) with maximum amplitudes of a few gammas in the polar regions; they are well synchronized around the world. Longer period continuous pulsations (LPc's) usually appear simultaneously with Pc's in polar regions.

An attempt is made to explain the characteristics of micropulsations in terms of hydromagnetic oscillations in the outer atmosphere excited by solar corpuscular streams. — D. B. V.

- 185-420. Law, P. F., and Fannin, B. M. Radiation from a current filament above a homogeneous earth, with application to micropulsations: *Jour. Geophys. Research*, v. 66, no. 4, p. 1049-1059, 1961.

The electric and magnetic fields in the vicinity of a plane, homogeneous earth due to a line current source above this earth model are examined in order to throw light on the origin of geomagnetic micropulsations. As the micropulsation frequencies are quite low (of the order of 1 cycle per second), the nearfield considerations become significant. The solution for this nearfield problem is presented, and the fields at the earth's surface are evaluated for a set of parameter values chosen to approximate an ionospheric source at a typical micropulsation frequency. — D. B. V.

- 185-421. Tepley, Lee R. Observations of hydromagnetic emissions: *Jour. Geophys. Research*, v. 66, no. 6, p. 1651-1658, 1961.

Preliminary results of a frequency-time analysis of geomagnetic micropulsations in the frequency range 0.5-5 cycles per second are presented. At times, oscillatory signals of slowly varying frequency were observed continuously for periods of several hours; signals of more rapidly varying frequency were also observed, but for shorter periods of time. The oscillations are

called hydromagnetic emissions, as they are probably generated above or high in the ionosphere and are propagated downward by hydromagnetic waves. The nature of the oscillations was undoubtedly influenced by solar-flare activity that occurred before and during the observation period. — D. B. V.

- 185-422. Terashima, Yoshinosuke. Solar modulation of primary cosmic rays: *Prog. of Theoretical Physics*, v. 23, no. 6, p. 1138-1150, 1960.

A combined model is developed to account for the modulation of cosmic rays by both disordered and ordered magnetic fields of solar origin. The diffusion region of disordered magnetic fields is assumed to extend widely over the solar system and to produce modulation of the low energy part of primary cosmic rays. An interpretation is given for the characteristic shape of the low energy spectrum common to all of the heavy primary cosmic rays recently observed. The eleven-year variations are ascribed to the superposition effect of ordered magnetic fields distributed near the earth's orbit. The diurnal variations are shown to be a direct consequence of the model; the solar streams with uniform magnetic fields will cause the quiescent diurnal variations as well as the ones associated with magnetic disturbances.

Arguments are based upon the assumption of two kinds of solar streams: the continuously ejected streams and the more intense ones produced by solar eruptions. A quantitative estimate of the physical parameters to describe the present model is given. — V. S. N.

- 185-423. Hu, Yue-jen. On the 27 day periodicity of the magnetic activity [in Chinese with English abstract]: *Acta Geophys. Sinica*, v. 7, no. 2, p. 103-107, 1958.

From analysis of magnetic data for 32 years, 1923-54, Hu has found that the frequency of international magnetically disturbed days (5 for each month) has a 27-day periodicity corresponding to the sun's rotation. This periodicity is apart from that of the well-known 27-day recurrence of magnetic activity. — V. S. N.

- 185-424. Nicholson, Seth B., and Wulf, Oliver R[eynolds]. The diurnal variation of K indices of geomagnetic activity on quiet days in 1940-1948: *Jour. Geophys. Research*, v. 66, no. 4, p. 1139-1144, 1961.

Local- and universal-time components of the diurnal variation of the K-indices have been computed from the 8 daily K numbers for the 10 quiet days of each month in the 9 years 1940-48 for 6 observatories in moderately low latitudes and fairly evenly distributed longitudes. The universal-time component is less regular than the local-time component. There is a pronounced change in form of the apparent regularity of the latter when it is examined for each of the 9 years separately. This change probably arises mainly from disturbance and represents a change in the relative amounts of disturbance having different forms of diurnal variation. It may represent a change of this distribution with the solar cycle. — D. B. V.

- 185-425. Takahashi, Hachiro. Correlation between solar activity and sudden movements in geomagnetic disturbances: *Jour. Geophys. Research*, v. 65, no. 12, p. 4206-4209, 1960.

Geomagnetic and solar data obtained at the Kakioka Magnetic Observatory in Japan in 1924-58 were used in a statistical study of long-term variations. In this letter, discussion is limited to sudden movements of horizontal intensity (H) in geomagnetic disturbances; a total of 786 of these (SC, SC*, and SI)

were used. The results are presented in graphs that show in different ways the correlations between duration and amplitude of ΔH movements and relative sunspot numbers. — D. B. V.

- 185-426. Fournier, Hugo. Quelques aspects des premiers enregistrements magnétotelluriques obtenus à Garchy dans la gamme des variations très rapides [Some aspects of the first magnetotelluric records obtained at Garchy in the range of very rapid variations]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 7, p. 963-964, 1960.

The first results obtained with the new apparatus for recording very rapid geomagnetic variations (see Geophys. Abs. 184-463) are reported. Fluctuations of less than 1 sec period are very uniform as compared to those of more than 1 sec period. Remarkable periodicities of the order of 0.12 sec are always present. Earth-current variations correspond precisely with the geomagnetic variations.

Without special precautions, the induction magnetometers act as very sensitive seismographs, recording microseismic agitation due to such factors as wind in nearby trees, distant quarry explosions, thunder, passing aircraft, or a bulldozer working several hundred meters away. — D. B. V.

- 185-427. Veldkamp, J. A giant geomagnetic pulsation: Jour. Atmos. Terrest. Physics, v. 17, no. 4, p. 320-324, 1960.

A giant geomagnetic pulsation on July 17, 1958 was recorded by many European observatories between 50° and 60° geomagnetic latitude. The movements (with periods of about 100 sec) were coherent in only a small part of the area in which they were recorded. Maximum amplitudes (25γ) occurred in a strip following the circles of geomagnetic latitude.

It is obvious that the direct cause of the pulsation cannot be the same at stations far apart. Examination of the theories of Obayashi and Jacobs (see Geophys. Abs. 181-372) and Scholte (see Geophys. Abs. 181-371) leads to the conclusion that the area over which this pulsation was recorded is an indication of the size of the area of the exosphere that was disturbed at its generation. The loss of coherence of the vibrations over a rather small distance and the shift of starting and ending times might be caused by the occurrences in the source; presumably the whole area was not disturbed at the same moment. — D. B. V.

- 185-428. Wescott, Eugene M. Magnetic variations at conjugate points: Jour. Geophys. Research, v. 66, no. 6, p. 1789-1792, 1961.

Magnetograms from Macquarie Island were compared with those from nine Alaskan International Geophysical Year stations, Fort Churchill, Canada, and Cape Chelyuskin, U.S.S.R. The magnetic variations at Macquarie Island were found to correspond remarkably well in universal time with those at several Alaskan stations. On the basis of this study an area lying roughly between Healy and Kotzebue, Alaska, can be defined as the area conjugate magnetically to Macquarie Island. — Author's abstract

- 185-429. Robertson, C. S. Magnetic bays at Macquarie Island: Australian Jour. Physics, v. 13, no. 3, p. 470-476, 1960.

Polar magnetic bays are the most striking feature of magnetic records obtained by the Australian National Antarctic Research Expeditions at Macquarie Island. Negative bays are more numerous than positive bays and have greater amplitudes and durations. As a rule negative bays commence about magnetic

midnight whereas positive bays commence about five hours earlier. A daily reversal in direction of the bay-producing currents is indicated, and the time at which this reversal takes place appears to vary with the seasons. During magnetically disturbed periods the ratio H-bay amplitude to Z-bay amplitude increases, indicating a northward movement of the bay-producing currents. At the same time auroras seen from Macquarie Island lie further north in the sky than usual. — Author's abstract

- 185-430. Rourke, G. F. Small-scale polar-cap absorption and related geomagnetic effect: *Jour. Geophys. Research*, v. 66, no. 5, p. 1594-1595, 1961.

The fact that on December 17, 1957 the level of geomagnetic activity was relatively more marked inside the polar cap than in the auroral zone (see *Geophys. Abs.* 184-467) may be related to the influx of corpuscular radiation. An intensification of the polar-cap current system due to energetic particles would result in a higher level of geomagnetic disturbance in the polar regions. The sudden commencement on December 19, reported at 37 stations, was followed by a period of slight disturbance ($A_p=20$). — D. B. V.

Kertz, Walter. Conducting cylinder in the transverse alternating magnetic field. See *Geophys. Abs.* 185-172.

- 185-431. Singer, S. F. A new model of magnetic storms and aurorae: *Am. Geophys. Union Trans.*, v. 38, no. 2, p. 175-190, 1957.

A model is proposed that explains the cause of SC*, the atmospheric nature of SC, the delay between SC and the main phase of a magnetic storm, and the formation and decay of the ring current. In this model, a shock wave from a solar eruption reaches the earth 22-24 hr later. High-velocity particles having smaller interaction precede the shock wave and cause pre-SC bay-like disturbances at high latitudes. The shock wave itself is retarded by body forces produced by the geomagnetic field but speeds up on entering auroral zones; in pushing out the lines of force it creates polar SC* events. The storm decrease is produced by high-velocity particles following the shock wave, which become trapped in the normally inaccessible Störmer region and drift, producing the ring current. — D. B. V.

- 185-432. Akasofu, Syun-Ichi, and Chapman, Sydney. The ring current, geomagnetic disturbance, and the Van Allen radiation belts: *Jour. Geophys. Research*, v. 66, no. 5, p. 1321-1350, 1961.

The large decrease in the horizontal component of the earth's field during the main phase of magnetic storms has been ascribed to the formation or enhancement of a geomagnetic ring current. The motions of particles trapped in the earth's dipole field and the resulting ring current are calculated. The general equations for the current intensity, to obtain the total current and the magnetic field at the earth's center, are applied to the outer radiation belt and to a special "model" belt V_3 . The results are considered in connection with magnetic records for several storms and with satellite data. It is inferred that during magnetic disturbance, protons of energy of the order of a few hundred kev are intermittently captured between 5 and 8 earth radii to produce a transient V_3 belt. Differences in development of the ring current from one storm to another may be connected with irregular distribution of particles in the solar stream, which may contain tangled magnetic fields. — D. B. V.

- 185-433. Ferraro, V. C. A. An approximate method of estimating the size and shape of the stationary hollow carved out in a neutral ionized stream of corpuscles impinging on the geomagnetic field: *Jour. Geophys. Research*, v. 65, no. 12, p. 3951-3953, 1960.

Using a formula which he derived in 1952, Ferraro has developed an approximate method for estimating the size and shape of the stationary hollow carved out when a solar corpuscular stream impinges on the geomagnetic field. It is also shown that in a two-dimensional magnetic field, the width of the hollow at infinity is finite and is given by $(2\pi I^2 / \rho v^2)^{1/2}$ where I is the current flowing in a permanent inducing system, ρ the density, and v the velocity of the stream. — D. B. V.

- 185-434. Piddington, J. H. A theory of polar geomagnetic storms: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 3, p. 314-332, 1960.

A hydromagnetic theory of geomagnetic storms is developed further (see *Geophys. Abs.* 179-294). The three phases of the longitude-dependent disturbance D_s , the first phase of Sc , the main phase, and the preliminary reverse are all accounted for in terms of hydromagnetic waves whose Poynting fluxes are directed along the magnetic lines of force. These disturbances originate from "electromagnetic friction" between the solar wind and geomagnetic lines of force near 06 h and 18 h local time. These lines of force are bent out of their meridian planes and cause two pairs of "twist" waves to reach the earth, focused into relatively confined regions at high latitudes. These twists are stable or force-free and result in space-charge accumulations in the lower atmosphere, where the resultant Hall current accounts for the observed disturbances.

During the main phase the twists are maintained by a deformation of the geomagnetic field, the geomagnetic "tail." Thus the tail theory accounts for both Dst and D_s main phase. It is difficult to see how any ring-current theory or other theory dependent on trapped corpuscular radiation could account for the asymmetric features of storms. The mechanism also provides the beginning of a theory for auroras. — D. B. V.

- 185-435. Simon, Paul. Les éruptions chromosphériques associées avec sursauts radioélectriques de type IV: effets ionosphériques et géomagnétiques [The chromospheric eruptions associated with radioelectric bursts of type IV: ionospheric and geomagnetic effects]: *Annales Astrophysique*, v. 23, no. 1, p. 102-110, 1960.

A study of ionospheric and geomagnetic effects associated with chromospheric eruptions leads to the conclusion that there is a close relation between chromospheric eruptions accompanied by type IV solar radioelectric bursts and sudden ionospheric disturbances (SID). A relation of the same sort exists with geomagnetic activity (characterized by the sum of daily K-indices), but here the correlation is more directly with the importance of the eruption. — D. B. V.

- 185-436. Durandea, Monique; Delloue, Jean; and Rocard, Yves. Oscillations de pression atmosphérique liées à un orage magnétique [Oscillations of atmospheric pressure related to a magnetic storm]: *Acad. Sci. [Paris] Comptes Rendus*, v. 251, no. 17, p. 1807-1809, 1960.

Simultaneous microbarographic oscillations recorded at three Pacific stations (Bora-Bora, Makatea, and Papeete) seem to have been caused by a wave of cosmic particles that were also manifested in the form of a magnetic storm. — D. B. V.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 185-437. Hall, J. M., and Neale, R. N. Stress effects on thermoremanent magnetization: *Nature*, v. 188, no. 4753, p. 805-806, 1960.

Experiments reported here show that the effect of stress on thermoremanent magnetization is not completely reversible in all cases as reported recently (see *Geophys. Abs.* 183-454). Tests made on a number of rocks containing different minerals in every case showed a rotation of moment induced by uniaxial pressure during magnetization, together with a reduction of moment. The observed rotation of moment depended on the pressure, on the angle between the magnetizing field and the pressure axis, and on the grain size of the magnetic constituents (composition being constant), but was apparently independent of the intensity of the magnetizing field in the range of 0.5-3.0 oersted.

The mechanism of these pressure effects is complex, but not irreconcilable with the known magnetostrictive properties of magnetite. There is a close similarity between the variation of rotation of moment with grain size and the variation of coercive force with grain size; if the latter variation results from a change in the mechanism of magnetization, it is obviously an important factor in the production of angular pressure effects.

A slight intrinsic anisotropy, together with the grain size factor, may have contributed to the experimental results that suggested complete reversibility of pressure effects. — D. B. V.

- 185-438. Stacey, F. D. Thermo-remnant magnetization (TRM) of multidomain grains in igneous rocks: *Philos. Mag.*, v. 3, no. 36, p. 1391-1401, 1958.

The magnetic moment of a multidomain grain at its blocking temperature is determined by the domain arrangement which gives the minimum magnetic energy; for a large grain the energy minimum is produced by a self-demagnetizing field equal and opposite to the external field. Below the blocking temperature the domain configuration is frozen in and the moment increases with the increasing spontaneous magnetization. This results in a TRM proportional to small inducing fields, as in the theory of single domain grains and as required for agreement with exponential observations. Artificial TRM's of 17 rocks for which analyses of magnetic minerals are available show good agreement with calculated values. The theory also gives a formula for the maximum possible initial susceptibility of rocks which agrees well with experimental observations. — Author's abstract

- 185-439. Irving, E. Robertson, W. A., Stott, P. M., Tarling, D. H., and Ward, M. A. Treatment of partially stable sedimentary rocks showing planar distribution of directions of magnetization: *Jour. Geophys. Research*, v. 66, p. 1927-1933, 1961.

It is shown how the viscous magnetization components in some Upper Carboniferous sediments may be removed by partial thermal demagnetization so that the initial planar distribution condenses around the direction of the stable magnetization. The demagnetization was carried out by heating in an inert atmosphere in a nonmagnetic oven followed by cooling in a zero field. Application of Graham's fold test shows that this stable magnetization is of very great antiquity, certainly pre-Triassic and probably pre-Permian in age. — D. B. V.

- 185-440. Opdyke, N. D. The paleomagnetism of the New Jersey Triassic: A field study of the inclination error in red sediments: *Jour. Geophys. Research*, v. 66, no. 6, p. 1941-1949, 1961.

It has previously been reported that on redeposition in the laboratory the magnetization of both red sediments and varves has a systematic error in inclination which could be a serious source of error in paleomagnetic work. To test whether such an error occurs in nature, the directions of magnetization measured in specimens from intrusions, extrusions, and red sediments of the Newark system have been compared. There is no significant difference between the stable directions in each type of rock, showing that no important error in inclination occurs in the sediments. — Author's abstract

- 185-441. Cox, Allan [V]. Anomalous remanent magnetization of basalt: *U.S. Geol. Survey Bull.* 1083-E, p. 131-160, 1961.

Anomalous remanent magnetization in igneous rocks is often characterized by varying intensity and direction throughout a magnetized body; regions within which a correlation exists between the remanent magnetization at any two points are known as cells of anomalous magnetization. Such cells are common to the Pliocene and Pleistocene basalts of Idaho; the magnetization is isothermal and probably is due to the intense magnetic field accompanying a lightning discharge with a peak current of 22,000 amps. The dimensions of the cells of anomalous magnetization in these lava flows are within the range of typical currents in lightning bolts, 20-100 feet. Viscous magnetization causes a much smaller anomalous magnetization in these rocks and is often masked by the isothermal magnetization due to lightning. The thermoremanent magnetization is relatively stable, but both types of anomalous magnetization can be selectively destroyed using alternating magnetic fields. — V.S.N.

- 185-442. Babkine, Jean, and Bolfa, Joseph. Contribution à l'étude des propriétés thermomagnétiques de quelques basaltes [Contribution to the study of the thermomagnetic properties of some basalts]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 13, p. 1979-1981, 1961.

Samples of the Etna flow of 1381 were studied in order to determine the precise mineralogic nature of the material responsible for the ferromagnetism of the lava. A sample from the center of the flow gave a thermomagnetic curve that shows a distinct discontinuity for a temperature of 120°C; the optical properties of its opaque elements are those of titanomagnetite. A sample from the upper part of the flow gave a curve similar to that of magnetite; its optical properties are heterogeneous and it shows typical epitaxial martitization. Five other samples from positions intermediate between these two gave intermediate curves. Similar results were obtained on three flows from the Velay region of France.

It is concluded that each flow is characterized by a group of curves, the type curve being that with the lowest Curie point. Unaltered internal zones and external zones oxidized by contact with the atmosphere can be distinguished within each flow. — D. B. V.

- 185-443. Pecherskiy, D. M. K voprosu o magnitnoy anizotropii sloistyykh gornykh porod [Problem of magnetic anisotropy of stratified rocks]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1490-1494, 1960.

The results of experimental studies on the relationship between the anisotropy of weakly and moderately magnetized rocks and their layering is reported. Cubic samples of sedimentary, volcanic, and metamorphic rocks, 1-6 cm³ in size were thermomagnetized parallel and transverse to the layering up to 700°C in a field of 3 oersteds, and their remanent thermomagnetism measured on a Dolginov astatic magnetometer. It was found that magnetic anisotropy of rocks is correlated with secondary layering due to unilateral pressure under high temperature. This has been observed in magnetite quartzite and schist (see *Geophys. Abs.* 166-270, 176-267). A suggestion is made that the degree of magnetic anisotropy of metamorphic rocks should reflect the degree of their metamorphism. — A. J. S.

- 185-444. Lapina, M. I. Ob ispol'zovanii variatsiy magnitnogo polya dlya opredeleniya magnitnoy vospriimchivosti sil'nomagnitnykh gornykh porod v usloviyakh yestestvennogo zalevaniya [On the application of magnetic field variations for determination of magnetic susceptibility of strongly magnetic rocks under conditions of natural occurrence]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 418-422, 1961.

From earlier studies (Yanovskiy, 1936) of the character of variation of the geomagnetic field in an anomalous region and as a result of model experiments, a method has been devised for determining the magnetic susceptibility K of rocks in their natural environment. It was found that K values can be determined in the field by measuring variations of the magnetic field over an anomalous body of known size. The measurements must be performed simultaneously with a magnetic survey of the region investigated. — A. J. S.

- 185-445. Brodskaya, S. Yu. Magnitnaya stabil'nost' ostatochnoy namagnichennosti dvukhkomponentnykh smesey [Magnetic stability of remanent magnetization of two-component mixtures]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 423-427, 1961.

Model studies of two-component mixtures (pyrrhotite and magnetite) are described, and a discussion of the results of these studies is undertaken to establish whether the value H_b of the demagnetizing field can be used as a laboratory criterion for the magnetic stability of such two-component mixtures. It was found that the demagnetizing field H_b is a function of the concentration of the components and can therefore be used as a criterion of the direction of remanent magnetization, and that two-component samples having $H_b > 40$ oersteds can be considered stable. — A. J. S.

Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean. See *Geophys. Abs.* 185-587.

Stacey, F. D., Lovering, J. F., and Parry, L. G. Thermomagnetic properties, natural magnetic moments, and magnetic anisotropies of some chondritic meteorites. See *Geophys. Abs.* 185-81.

- 185-446. Runcorn, S. K[ith]. Magnetismo de las rocas [Rock magnetism]: *Rev. Geofísica*, v. 19, no. 75, p. 257-267, 1960.

This is a review of the history of the geomagnetic field as deduced from paleomagnetic measurements, and the significance of those measurements in terms of continental drift, polar wandering, and paleowind evidence. — D. B. V.

- 185-447. Irving, E. Paleomagnetic methods: A discussion of a recent paper by A. E. M. Nairn: *Jour. Geology*, v. 69, no. 2, p. 226-231, 1961.
Nairn, A. E. M. Paleomagnetic results from Europe: A reply to E. Irving: *ibid*, p. 231-235, 1961.

It is Irving's contention that a tendency exists to publish paleomagnetic pole positions accompanied by little or no evidence (1) that the directions obtained in the laboratory are those of the geomagnetic field at the time the rocks were laid down; (2) that an adequate time coverage has been insured—the primary magnetism of samples from a representative rock unit should have been acquired over a period of time longer than 10^4 yr but not greatly exceeding 10^7 yr; and (3) that the results are obtained and analyzed in a consistent fashion appropriate to the assumptions made. Nairn's European results (see *Geophys. Abs.* 181-386) were chosen for analysis because they represent a substantial proportion of the paleomagnetic pole determinations from Europe. Irving claims that Nairn has measured the direction of natural remanent magnetization in specimens from certain rock formations and interpreted these without regard to the above requirements.

Nairn claims in reply that no reference was made to stability, with exception of the Triassic where an arbitrary and not wholly satisfactory technique was described. In "Paleomagnetic results from Europe" the attempt was made to show that, excluding the problem of the Carboniferous, there was general agreement between the measurements made on rocks of the same age from various parts of Europe, although some collections were small. Nairn does not feel it is necessary to modify the conclusions reached in his paper. — V.S.N.

- 185-448. Collinson, D. W., and Creer, K. M. Measurements in palaeomagnetism, in *Methods and techniques in geophysics*, v. 1: New York, Interscience Publishers, Inc., p. 168-210, 1960.

In part 1 of this paper, the only two instruments with the necessary high degree of sensitivity for measuring the magnetic fields associated with remanent magnetization of sedimentary and igneous rocks are described in detail. These are the spinner or rock-generator magnetometer and the astatic magnetometer. In part 2, the investigation of other magnetic properties of rocks is discussed as follows: measurement of susceptibility, measurement of saturation magnetization and hysteresis plotting at different temperatures, apparatus for study of temperature effects, and demagnetization by alternating magnetic fields. — V.S.N.

- 185-449. Cox, Allan [V.], and Doell, Richard R. Paleomagnetic evidence relevant to a change in the earth's radius: *Nature*, v. 189, no. 4758, p. 45-47, 1961.

The expanding earth hypothesis is tested by means of calculations based on paleomagnetic results. It is assumed that the continents have not increased in area and that the ancient geomagnetic field was a dipole. The method of finding the ancient radius is essentially the one originally used by Eratosthenes to obtain the present earth radius from astronomical data.

A radius of 6,310 km is calculated for the Permian period, using data from 16 igneous and sedimentary rocks from western Europe and 5 igneous rocks from Siberia. Comparison with the present radius of 6,370 km leads to the conclusion that the average Permian magnetic field shows no significant departure from the dipolar configuration and is consistent with a Permian earth

radius equal to the present one. An increase in radius as slow as that suggested by Egyed (see Geophys. Abs. 182-267) is neither confirmed nor rejected by paleomagnetic data now available, but an increase as large as that suggested by Carey (see Geophys. Abs. 178-217) appears unlikely. — D. B. V.

- 185-450. Rutten, M. G. Paleomagnetic study of younger volcanic series: Geol. Rundschau, v. 49, no. 1, p. 161-167, 1960.

Paleomagnetic dating of younger volcanic rocks is discussed on the basis of the direction (normal or reversed) of thermoremanent magnetization; the slower aperiodic drift of the magnetic pole is not considered. The direction of magnetization can be measured in the field with a geologic hand compass. As a correlation method it should be used in conjunction with geologic mapping, for the correlation of sections far apart on a paleomagnetic basis alone may lead to false conclusions. In the Auvergne, France, the reversals of the geomagnetic field have been correlated with a known stratigraphic column (see Geophys. Abs. 174-282). — D. B. V.

- 185-451. Kochegura, V. V. Paleomagnitnyye metody vozrastnoy korrelyatsii gornykh porod [Paleomagnetic methods of age correlation of rocks]: Sovetskaya Geologiya, no. 4, p. 47-59, 1961.

The path of migration of the magnetic poles of the earth is one method of stratigraphic correlation. This method can be used where the rocks are sufficiently stable magnetically and where the tectonic history is known. An approximate absolute age is obtained. A second method of correlation makes use of reversals in the magnetic field. Although this technique is well suited for stratigraphic correlation, no indication of absolute age is given. A third method is based on the demagnetization of rocks with time and yields an approximate absolute age. — J. W. C.

- 185-452. Rezanov, I. A. O dreyfe kontinentov (po paleomagnitnym dannym) [Drift of continents (according to paleomagnetic data)]: Sovetskaya Geologiya, no. 4, p. 25-46, 1961.

Magnetic and geographic pole transference in the course of geologic time appears to be well established. The first approximations of paleomagnetic pole measurements agree with the results of paleoclimatic reconstructions. Continental drift, however, cannot be proved on the basis of paleomagnetic data for the following reasons: The accuracy of paleomagnetic measurements is very low and is applicable only to shifts of 2,000 km and more. Sufficient data for statistical determinations is available only for North America, western Europe, and the European part of U.S.S.R. The discrepancy between the North American and European data is due to a systematic error proportional to time. This error arises from an imperfect stability of specimens—the appearance of magnetization caused by a later magnetic field with a resulting shift of 10° - 15° toward the present magnetic field. The data for all the other continents is insufficient for use with the statistical method. — J. W. C.

- 185-453. Jaeger, J. C., and Irving, E. Palaeomagnetism and the reconstructions of Gondwanaland: Pan Indian Ocean Sci. Cong., 3rd, Tananarive, Proc., sec. C, p. 233-242, 1957 (1960).

The fundamental assumption is made that the earth's magnetic field when averaged over a period of a few thousand years is that of a dipole along its axis of rotation. Pole positions in the geologic past can be calculated, and both polar wandering and continental drift should be detectable. As longitude

cannot be determined by this method, many ambiguities arise in reconstructions. Much more data are required before the problem can be discussed adequately. — J. W. C.

- 185-454. Dauvillier, Alexandre. *Paléomagnétisme et paléoclimatologie* [Paleomagnetism and paleoclimatology]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 3, p. 371-373, 1961.

Dauvillier has suggested (see Geophys. Abs. 184-440) that geomagnetism is caused by and maintained by solar activity, and that the magnetic axis has never deviated very far from the axis of rotation. The pole positions deduced from paleoclimatic data agree well with those deduced by Roche from the magnetization of Auvergne lavas (see Geophys. Abs. 182-412) and by Nagata from that of the Miocene lavas of Japan (see Geophys. Abs. 180-290), but do not agree at all with the polar wandering curve of Opdyke and Runcorn (see Geophys. Abs. 176-275).

The paleoclimatic polar wandering curve shows 4 simple oscillations in the last 300 million years, rapidly damped toward an equilibrium position at a quasi-uniform rate (of the order of 1° per million years) with a final acceleration to 20° per million years. It is impossible to learn the geographic position of the axis of rotation 4.5 billion years ago when geomagnetism began because the 20-odd km of magnetized superficial rocks have undergone changes due to volcanism, sedimentation, orogenesis, and erosion since that time. Geomagnetism appears to be entirely renewed every 300 million years at least. — D. B. V.

- 185-455. Ma, Ting Ying H. A comparison of paleomagnetic latitudes and paleogeographical latitudes deduced from growth values of reef corals: *Oceanographica Sinica*, v. 6, no. 2, 5 p., 1960.

The relative positions of continents and the paleogeographic latitudes of different places and of pole positions from Ordovician to Permian and in Late Cretaceous based on the growth values and distribution of fossil reef corals are discussed. A comparison is made with the paleomagnetic latitudes and magnetic pole positions from the evidence of remanent magnetism; it is shown that the ecological determinations support the paleomagnetic determinations. — V. S. N.

- 185-456. Irving, E., and Banks, M. R. Paleomagnetic results from the Upper Triassic lavas of Massachusetts: *Jour. Geophys. Research*, v. 66, no. 6, p. 1935-1939, 1961.

The directions of magnetization at 5 sites in 2 lava members of the Newark group of Massachusetts have been measured and found to have fairly consistent northerly declinations but highly variable inclinations. This variation is shown to be due to the presence of a soft magnetic component of variable magnitude approximately parallel to the present earth's field; its effect is removed in alternating magnetic fields of 150 oersteds. The magnetization remaining after removal of this soft component has a mean direction of 010° , $+16^\circ$, which is consistent with the paleomagnetic pole position at lat 55° N., long 88° E. This agrees well with other Triassic paleomagnetic pole determinations from the United States. — D. B. V.

- 185-457. Hood, Peter J. Paleomagnetic study of the Sudbury basin: *Jour. Geophys. Research*, v. 66, no. 4, p. 1235-1241, 1961.

In a reconnaissance paleomagnetic study of the Precambrian nickel irruptive of the Sudbury basin in Ontario, the remanent magnetism vectors of 226 specimen cubes cut from 60 oriented samples collected along 5 traverses were measured with a "spinner" magnetometer. The directions of magnetization for the south range are closely grouped on the Schmidt equal-area plot, indicating negligible rotary movement since the irruptive last cooled through the Curie point of its magnetic constituents. Directions for the north and south ranges differ by about 40° , suggesting that there has been relative tilting about an east-west axis through the middle of the basin. If the assumed rotation is equally divided between the two ranges, the resultant pole position is lat 38.4° N., long 99.4° W., in the central United States.

Magnetic susceptibility of the samples is higher in the north range than in the south, and in three of the south range traverses it is higher on the south end of the traverse than on the north end. The magnetic anomalies over the norite sections of both ranges appear to be due mainly to remanent magnetization, and only to a lesser extent to induced magnetization. — D. B. V.

- 185-458. Einarsson, Trausti. Jördeldasvaedid um nordanverdan Skagafjord. Aldursakvördun á landslagi á Midnordurlandi [Pleistocene volcanism in the north of Skaga Fjord and the paleomagnetic dating of topography in middle northern Iceland (with English summary)]: *Nattúrufraedingurinn*, v. 29, no. 3, p. 113-133, 1959.

The topography of middle northern Iceland is characterized by broad valleys and plains graded to a base level that now stands at 300 m elevation. A younger standplain occurs at 80-100 m elevation and is overlain by lava flows that exhibit both reverse and normal polarity. Where both types occur in the same section, the reverse is below and the normal is above. On the assumption that a change in the polarity of the earth's magnetic field from reverse to normal took place near the beginning of the Pleistocene, it is assumed that the standplain was fully developed in pre-Pleistocene time. — J. W. C.

- 185-459. Everitt, C. W. F. Rock magnetism and the origin of the Midland basalts: *Royal Astron. Soc. Geophys. Jour.*, v. 3, no. 2, p. 203-210, 1960.

Paleomagnetic measurements on the Carboniferous igneous formations known as the Midland basalts, which occur in the vicinity of the Cleve Hills in Shropshire, England, support Marshall's arguments that all are intrusive except Little Wenlock. Little Wenlock, which occurs in the Carboniferous limestone, must be older than the intrusions in the Millstone Grit. The mean direction of magnetization for Little Wenlock is 355° E. and 7° down, whereas that for the Cleve Hill, Kinlet, Shatterford, and Pouk Hill sites is 202° E. and 17° down.

The sites at Barrow Hill and Rowley Regis have not been studied in detail; their magnetic directions agree well with those of the other intrusions, suggesting that they were formed at the same time. The overall mean direction for the intrusions, 200° E. and 17° down, agrees well with other paleomagnetic results for the Carboniferous period (Everitt and Belshé), confirming the dating of the formations as Carboniferous.

The measurements also suggest that intrusion occurred before folding of the country rock. At Shatterford they indicate that the accepted geologic interpretation should be reexamined. Some of the Shatterford rocks have probably undergone self-reversal. — D. B. V.

- 185-460. Creer, K. M., Irving, E., and Runcorn, S. K[ith]. The palaeomagnetic poles for the Lower Jurassic of Europe: Royal Astron. Soc. Geophys. Jour., v. 3, no. 3, p. 367-370, 1960.
- Girdler, R. W. Comment by R. W. Girdler: *ibid.*, p. 371-373, 1960.

Girdler's conclusion that the direction of the Early Jurassic geomagnetic field was significantly different from the present dipole field, corresponding to a pole lying in the region of the Caspian Basin, based on his paleomagnetic study of some Lower Jurassic rocks of northwestern Europe (see Geophys. Abs. 179-319), is challenged by Creer, Irving, and Runcorn, who inferred quite a different pole position for that time (see Geophys. Abs. 173-296), as did Hargraves and Fischer (see Geophys. Abs. 177-300). Girdler's results are open to the alternative explanation that there is a secondary magnetization superposed on the present dipole field in addition to the primary or original magnetization. His use of a statistical method appropriate to a symmetrical distribution in checking magnetic stability is hardly appropriate in this case. His observations do not enable any significant statement to be made concerning the position of the geomagnetic pole relative to western Europe during the Early Jurassic.

Girdler defends his interpretation, giving several reasons why there is no good evidence that a secondary component of magnetization is important in the Midford and Cotswold sands. The easterly declination found for the Early Jurassic is slightly larger than that for the Triassic, and the fairly steep inclination of 67° is very close to that found by Nairn (see Geophys. Abs. 170-242); it is also pointed out that the rocks of Hargraves and Fischer come from a thrust area and are unusually tightly clustered. The smoothed polar wandering curve of Creer, Irving, and Runcorn assumes no continental movements or local movements of the earth's crust; as more and more results become available it is possible that their polar wandering curve will become much more complex. — D. B. V.

- 185-461. Dietzel, G. F. L. Geology and Permian paleomagnetism of the Merano region, Province of Bolzano, N. Italy (with Dutch and Italian summary): *Geologica Ultraiectina*, no. 4, 58 p., 1960.

The stratigraphy and structure of the Merano area are discussed, and it is concluded that the geologic data are in accord with van Bemmelen's concept of the east-alpine structural evolution. The paleomagnetic properties of the Permian quartz-porphyrries at the northwestern margin of the Bolzano volcanic province were studied. The Permian magnetic south pole position deduced from the average direction of magnetization is lat 146° W., long 45° N. Although the latitude agrees with that of pole positions for other Permian rocks of the European continent, the longitude deviates about 40° . This divergence of the north Italian Permian magnetic pole might be the result of secular variation. However, a tectonic cause, such as a counter-clockwise rotation of the Merano region around a vertical axis, might also explain it. — V. S. N.

- 185-462. Nijenhuis, G. H. W. A palaeomagnetic study of the Permian volcanics in the Nahe region (SW. Germany): *Geologie en Mijnbouw*, v. 40, no. 1, p. 26-38, 1961.

Pole positions calculated on the basis of paleomagnetic measurements of 57 samples from 2 Permian lava flows in the Nahe syncline in southwest Germany are lat 48° N., long 168° E. for the Grenzlager melaphyre and lat 42° N., long 163° E. for the Winnweiler Lager tholeiite. Together with measurements

on another flow, 3 sills, and a quartz porphyry intrusion, these measurements confirm the sequence established for the region by purely geologic means: intrusion of sills—intrusion of quartz porphyry—extrusion of lava—folding.

Comparison with Schmucker's results (see Geophys. Abs. 180-286) demonstrates the importance of magnetic cleaning in paleomagnetic research. — D. B. V.

- 185-463. Bukha, V. Nekotoryye rezul'taty paleomagnitnykh issledovaniy na pervichnykh isverzhenykh porodakh v Chekhoslovakii [Some results of paleomagnetic investigations on the primary volcanic rocks in Czechoslovakia]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 54-59, 1961.

Cambrian porphyries and porphyrites from the Tyrzhovitse, Skryy, and Zbiroga regions in Czechoslovakia were investigated for remanent magnetization. They show a variation of the earth's magnetic pole position as follows: $\phi = 9^\circ - 66^\circ$ and $\lambda = 134^\circ - 282^\circ$. Values of K range from $2,600 \times 10^{-6}$ to $14,900 \times 10^{-6}$ gauss and I_r from $1,100 \times 10^{-6}$ to $1,300 \times 10^{-6}$ gauss. — A. J. S.

- 185-464. Kruglyakova, G. I. Rezul'taty paleomagnitnykh issledovaniy po Ukrainskomu kristallicheskomu massivu i prilgayushchim rayonam [Results of paleomagnetic investigations in the Ukrainian crystalline massif and adjacent regions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 238-244, 1961.

The results of paleomagnetic investigations of the Ukraine crystalline massif are presented, and the methods of collection of the rocks are described. The path of migration of the earth's north magnetic pole is shown. It was established that the earth's magnetic pole has always been situated near the earth's geographic pole. Paleomagnetic investigations should be based on determination of both the vector of remanent magnetization and the value of the ratio $Q = I_r/I_s$ and not on the value of remanent magnetization alone. Paleomagnetic determinations of the relative ages of rocks were found to agree with geological and absolute ages (see also Geophys. Abs. 184-53). — A. J. S.

- 185-465. Forsh, N. N., and Khramov, A. N. Paleomagnetizm i paleoklimaty na Russkoy platforme v karbone i permi [Paleomagnetism and paleoclimates on the Russian platform in the Carboniferous and Permian]: Akad. Nauk SSSR Doklady, v. 137, no. 1, p. 154-157, 1961.

The geomagnetic pole positions in 9 different epochs during Carboniferous and Permian time have been calculated from paleomagnetic measurements on different formations from the Russian platform. Results are presented in a table and in the form of paleomagnetic parallels superposed on paleoclimatic maps for 6 epochs. Correspondence between paleoclimatic and paleomagnetic results is good. Apparently displacements of geographic latitude have occurred not only between the Caledonian, Hercynian, and Alpine cycles but have been continual throughout geologic history, having occurred from epoch to epoch and within epochs. — D. B. V.

- 185-466. Lin'kova, T. I. Laboratornyye issledovaniya yestestvennoy ostatochnoy namagnichennosti pryamo i obratno namagnichennykh gornykh porod Devona [Laboratory investigations of natural remanent magnetization of directly and inversely magnetized Devonian rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 91-95, 1961.

Laboratory paleomagnetic investigations of Devonian rocks of the Russian platform are reported (see also *Geophys. Abs.* 183-464). The purpose of the investigation was to obtain experimental facts in support of either the hypothesis of reversal of the earth's magnetic field or the hypothesis of self reversal due to physical-chemical processes in the rock. This was done by a determination of the stability of directly (N) and inversely (R) magnetized rock samples. It was found that the samples investigated are magnetically stable, and demagnetization in permanent and alternating magnetic fields does not show any difference in the behavior of the I_n vector. Thermomagnetic analysis shows that both the normal and reversed magnetic samples contain the same minerals, which is shown also by the petrographic and chemical analysis of the samples. The results of the investigation support the hypothesis of a reversal of the earth's magnetic field. — A. J. S.

- 185-467. Deutsch, E. R., and Watkins, N. D. Direction of the geomagnetic field during the Triassic period in Siberia: *Nature*, v. 189, no. 4764, p. 543-545, 1961.

The direction of magnetization of 5 oriented samples from Lower Triassic rocks in different parts of Siberia furnishes a Triassic north pole in Eastern Siberia at lat 65° N., long 156° E.; the semiaxes of the 95 percent confidence ellipse are $\delta m = 15\frac{1}{2}^\circ$, $\delta p = 14\frac{1}{2}^\circ$. This result differs from 3 of 4 pole positions for North America and more drastically from the African and Australian poles.

Comparison of global non-Triassic data has revealed many similar discrepancies: the separation of the European and Indian curves exceeds 90° for the Jurassic, the earliest period for which Indian data are available. This can be explained by invoking large relative displacements between the two land masses, and by implication, between India and northern Asia. A direct comparison with the Siberian results must await examination of suitable Triassic exposures in India. — D. B. V.

- 185-468. Momose, Kan'ichi, Kobayashi, Kunio, and Yamada, Tetsuo. Paleomagnetic and geologic researches for the volcanic rocks around Lake Suwa. Paleomagnetic researches for the Pliocene volcanic rocks in Central Japan (2): Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 433-481, 1959.

Continuing the paleomagnetic study of the Pliocene lavas of central Japan (see *Geophys. Abs.* 178-298), the results of paleomagnetic measurements on numerous samples of the Enrei formation (chiefly andesitic lavas and tuff-breccias) are presented in detail. The magnetic pole seems to have circled westward about the present south geographic pole during Enrei time, which is assigned to Late Pliocene on the basis of the reversed magnetization. — D. B. V.

- 185-469. Coombs, D. S., White, J. R., and Hamilton, D. Age relations of the Dunedin volcanic complex and some paleogeographic implications—Part II: *New Zealand Jour. Geology and Geophysics*, v. 3, no. 4, p. 572-579, 1960.

Paleobotanical, geomorphic, and paleomagnetic evidence are considered in an attempt to establish the duration of the Dunedin volcanic activity in New Zealand. Lavas of the first, of the lower part of the second, and of the third major eruptive phases are normally magnetized; those of the upper part of the second are inversely magnetized. If worldwide correlations on paleomagnetic evidence are valid, the inversely magnetized lavas were erupted during the

Late Miocene-basal Pliocene period of reversal recognized in France (see Geophys. Abs. 148-13320 and 167-205), and the volcanism must have ceased before the mid-Pliocene reversals. — D. B. V.

185-470. Blundell, D. J. The palaeomagnetism of some igneous rocks from Antarctica: *Polar Rec.*, v. 10, no. 67, p. 349-352, 1961.

Paleomagnetic studies were made on more than 600 oriented samples collected during 1955-58 in Antarctica as a part of a test of the hypothesis of continental drift carried out on continents that are supposed to be fragments of Gondwanaland. Results show that since the early Tertiary the earth's magnetic field has remained essentially constant in this part of the world; an exception is found in three mid-Tertiary lava flows of James Ross Island where the paleomagnetism is grouped exactly opposite to the present dipole field. Results from Jurassic intrusives show a mean direction significantly different from both the present field and the present dipole fields. Excellent agreement over a distance of continental magnitude shows that the earth's field in Jurassic times had the same dipolar character that it has had since the Oligocene. Pole positions plotted for Jurassic rocks from all the Gondwanaland continents have a wide scatter that can be explained only if a relative displacement of the continents is assumed to have occurred. — V. S. N.

MAGNETIC SURVEYS

185-471. Whitham, K[enneth], and Niblett, E. R. The diurnal problem in aeromagnetic surveying in Canada: *Geophysics*, v. 26, no. 2, p. 211-228, 1961.

Errors in aeromagnetic survey results due to geomagnetic time variations have been analyzed in two ways. In the first, properties of average magnetic disturbance have been calculated for 5 locations well distributed in latitude in Canada, and the autocorrelation functions of vertical magnetic field fluctuations have been used to estimate the errors as a function of the base loop length and length of the traverse lines or profiles for 5 latitudes. In practical applications, the root mean square (rms) errors are proportional to the square root of elapsed time. These results can be explained in terms of the shape of the autocorrelation functions, and models of disturbance that might produce them are discussed.

In the second part, experimental results are presented of a comparison of total field intensity fluctuations measured at two pairs of stations in western Canada south of the auroral zone. The rms differences in the time variations have been determined for each hour for both pairs of stations and found to be proportional to the rms level of magnetic activity and to the separation of the stations. The frequency distributions of the rms differences between the two pairs of stations for September 1959 have been determined.

Comparison of the two methods of correction indicates that in this region they are about equally accurate. Operational considerations are mentioned. — D. B. V.

185-472. Kutscher, Fritz. Erfahrung bei erdmagnetischen Untersuchungen auf Basaltvorkommen [Results of geomagnetic investigations on basalt occurrences]: *Deutsche Geol. Gesell. Zeitschr.*, v. 112, pt. 1, p. 171-177, 1960.

The general results of geomagnetic investigations on basalt bodies to date are compiled. It is possible to find and to outline bodies of basalt or basaltic tuff by the magnetic method, but for unambiguous interpretation of the data the geologic evidence must be considered. Basaltic rocks are sometimes magnetized in the direction of the present earth's field, sometimes in other directions; the reason for this behavior can be attributed in some cases to the nature of the material, in others to the geomagnetic field at the time of formation of the body. The magnetic study of basalts is valuable not only for scientific purposes but also for practical purposes in the quarrying industry. — D. B. V.

- 185-473. Devitsyn, V. M., Lapina, M. I., and Shneyerson, B. L. O vliyanii neodnorodnoy namagnichennosti tela postoyannoy vospriimchivosti na rezul'taty interpretatsii magnitnykh anomaly prosteyshimi metodami [On the effect of nonuniform magnetization of a body of permanent susceptibility on the results of interpretation of magnetic anomalies by simplest methods]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 428-432, 1961.

An attempt is made to determine the magnetic field Z_a of the iron ore deposit at Shchigry in the Kursk magnetic anomaly by assuming a nonuniform magnetization under a constant susceptibility and by comparing the results obtained with the observed data. It was found that the assumed nonuniform magnetization cannot explain the value of the anomaly investigated when the observed value of $K=0.2$ CGSM is given and the factor of remanent magnetization disregarded. — A. J. S.

- 185-474. Henderson, R[oland] G. Polar charts for evaluating magnetic anomalies of three-dimensional bodies, in Geological Survey research 1960: U.S. Geol. Survey Prof. Paper 400-B, p. B-112-B-114, 1960.

A new graphical method is presented for rapid computation of total-magnetic intensity anomalies of three-dimensional bodies. A single chart superimposed upon horizontal sections of the body reduces calculation to a simple counting of chart elements. The counting can be effectively performed on a commercially available optical analogue computer. — Author's abstract

- 185-475. Jacobsen, Peter, Jr. An evaluation of basement depth determinations from airborne magnetometer data (with discussion): *Geophysics*, v. 26, no. 3, p. 309-319, 1961.

This is virtually the same paper as previously published in *Bol. Inf.*, v. 3, no. 7, p. 199-207, 1960 (see *Geophys. Abs.* 184-500). — D. B. V.

- 185-476. Veynberg, A. K. Graficheskiy sposob opredeleniya glubiny namagnichennykh tel [Graphical method of determination of the depth of magnetized bodies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 60-68, 1961.

A graphic method for calculation of the depth to the upper edge of magnetically disturbing bodies, based on the form of their anomalies ΔT , Z_a , and H_a , is proposed and discussed. The method was tested on the magnetometric data of a ΔT survey of the northern part of the Turgai depression and was found applicable for bulk standard treatment of ΔT airborne survey data. Primary large scale magnetograms of high quality are essential for a satisfactory application of the method proposed. — A. J. S.

- 185-477. Bulakh, Ye. G. *Primeneniye elektronnykh vychislitel'nykh mashin dlya interpretatsii gravitatsionnykh i magnetnykh anomalii* [Application of electric calculating machines for interpretation of magnetic and gravity anomalies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1778-1781, 1960.

Three basic directions in application of computers are discussed in this paper: (1) the computation of various kinds of master charts, tables, nomograms, and other interpretation aids; (2) programming and solving a definite problem for determination of the parameters of a disturbing body; and (3) construction of specialized calculating devices for interpretation of anomalies. Examples are given for (1) and (2). — A. J. S.

- Bullard, E. C. The automatic reduction of geophysical data. See Geophys. Abs. 185-228.

Van Wambeke, L. Contribution to the study of the mineralogy, geochemistry, and methods of prospecting of pyrochlore-bearing carbonatites by means of X-rays. See Geophys. Abs. 185-498.

- 185-478. Rose, Edward R. Iron and titanium in the Morin anorthosite, Quebec: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-11, 12 p., 1960.

The general geology, petrography, geochemistry, magnetic anomalies, and economic geology of the Morin anorthosite composite intrusion are discussed. Titaniferous magnetite and massive ilmenite deposits are associated with this intrusion. The ilmenite deposits produce weakly negative magnetic anomalies and the titaniferous magnetite strongly positive anomalies. The strength of an anomaly does not always indicate the grade or amount of iron-titanium oxide minerals present, but it does serve as a guide to the relative concentration of the iron minerals. — V. S. N.

- 185-479. Gregory, A[lan] F., Bower, Margaret E., and Morely, L. W. Geological interpretation of aeromagnetic profiles from the Canadian Arctic Archipelago: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Paper 60-6, 13 p., 1960.

The geological significance of the aeromagnetic data of a reconnaissance airborne survey conducted in the Arctic Archipelago in 1955 is discussed. The aeromagnetic profiles show irregular regional and small local anomalies over Archean and pre-Pennsylvanian basement, frequent local and often very intense anomalies over the fold and dike belt at the east end of the Sverdrup basin, and smooth, flat profiles over thick sedimentary sequences. Depths to basement were calculated. Ferromagnetic bodies occur in six types of geological environment in the area; the bodies in the Precambrian rocks and within the Sverdrup basin appear to be the most extensive and probably are the major influence on the magnetic anomaly field. — V. S. N.

- Ghigone, João Ítalo. Gravity and magnetic reconnaissance in the Pelotas Basin. See Geophys. Abs. 185-318.

Scheffer, V[iktor]. Some contributions to the geophysical knowledge of the Carpathian basins. See Geophys. Abs. 185-323.

- 185-480. Varlamov, A. S., Mikhaylov, I. N., Nikitin, A. A., Puchkov, Ye. P., and Tarkhov, A. G. *Nekotoryye osobennosti metodiki obrabotki rezul'tatov geofizicheskikh issledovaniy pri pryamykh poiskakh*

almazov v Yakutskoy ASSR [Some features of the method of treatment of the results of geophysical investigations in direct exploration for diamonds in the Yakutsk A. S. S. R.]: Vyssh. Ucheb. Zavedeniya, Geologiya i Razvedka, no. 12, p. 88-97, 1960.

The discovery of the original diamond fields in the Yakutsk A. S. S. R. was accomplished by wide use of ground and air magnetic surveys. The kimberlite pipes contain a small amount of magnetite and are intrusive into limestones and dolomites. One of the principal tasks is to distinguish between these pipes and trap rocks. This can be accomplished by constructing rose diagrams for the direction of isodynamic lines of ΔZ ; the patterns are distinctive for each rock type. Gravity surveying is not very effective because of the great range in density of the kimberlite. — J. W. C.

185-481. Bernshteyn, V. A. O magnitnom pole na vulkane Zavaritskogo (ostrov Simushir, Kuril'skiye ostrova) [On the magnetic field on Zavaritskiy Volcano (Simushir Island, Kurile Islands)]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 30, p. 55-68, 1960.

A magnetic survey was made in the caldera of Zavaritskiy Volcano in the Kurile Islands in August 1958 following the eruption that began in November 1957. Results are tabulated and presented in profiles. In the eastern part of the caldera, vertical magnetic intensity ranges from +900 γ to +2,400 γ , and in other accessible parts from -1,400 γ to -5,000 γ with respect to points far outside the caldera. The vertical component of remanent magnetization of the most common rock (andesitic lava) reaches 1.4×10^{-2} gauss and thus accounts for the negative magnetic field in the central part of the core. Anomalies due to the eruptive apparatus in the caldera are not distinguishable. The vertical anomalies are interpreted as indicating a magnetic layer extending from about 40 to about 240 m in depth with a surface dipping at about 49.5°. This surface may be a fault contact. — D. B. V.

185-482. Agocs, W[illiam] B., Paton, J. R., and Alexander, J. B. Airborne magnetometer and scintillation counter survey over parts of Johore and Malacca (Area 5): Federation Malaya Geol. Survey Econ. Bull., C-1.5, 25 p., 1959.

This is the fifth in a series of publications reporting the results of airborne-magnetometer and scintillation-counter surveys conducted during 1956-57 over nearly 16,000 sq mi of Malaya. The same outline is followed as that used in Bulletin C-1.1 (see Geophys. Abs. 180-314). Area 5 comprises 1,592 sq mi of the western coastal area of Johore immediately south of Malacca. It was selected for the determination of the igneous-sedimentary boundaries and to locate possible extensions of the small known iron-ore deposits. The survey revealed one anomaly with values comparable with that for the Bukit Besi area in Trengganu (see Geophys. Abs. 180-315); it may indicate ferriferous ore in the basic intermediate igneous rocks, and an investigation is recommended. A smaller anomaly northwest of Ayer Hitam may reflect ferriferous or manganese concentrations. — V. S. N.

185-483. McMurtrie, I. H., and Moorcroft, E. Gravity and magnetic traverses over aeromagnetic anomaly—hundred of Carina: South Australia Dept. Mines Mining Rev., no. 110, p. 71-77, 1960.

The results of a magnetometer and gravimeter ground survey of an aeromagnetic anomaly near Minnipa, Eyre Peninsula, centered in sec. 40, hundred of Carina, are reported. A zone of rock 15,000X15,000 feet slightly

more dense than that of the surrounding area is indicated. Irregular occurrences of magnetic minerals are associated with the zone at depths of less than 400 feet. The zone of denser material apparently extends deeper. A drilling program is recommended. — V. S. N.

MICROSEISMS

- 185-484. Darbyshire, J. Microseisms and storms: *Adv. Sci.*, v. 17, no. 66, p. 149-157, 1960.

The origin of microseisms from pressure fluctuations on the sea bottom by the stationary or standing sea waves produced under storm conditions and techniques of locating storm bearings from microseisms are discussed in detail. A method is presented for estimating storm bearings by considering the actual nature of the microseismic wave. Assuming that microseisms consist of both Rayleigh and Love waves, the direction of storm approach is found by correlating the vertical, N-S, and E-W components. A new type of electronic seismograph used with a simple correlation amplitude and period meter that makes it possible to analyze and correlate the microseisms as they are recorded is described. The seismographs and correlation meters are portable, and it is proposed to set up mobile stations combining the older tripartite method of storm tracking with the correlation technique. — V. S. N.

- 185-485. Bernard, P[ierre]. Un sismographe étalon pour l'étude des micro-séismes [A standard seismograph for the study of microseisms]: *Annales Géophysique*, v. 16, no. 3, p. 419-421, 1960.

Records of the vertical Galitzin seismograph at the Parc Saint-Maur station in France have been used as the standard of comparison of relative amplitude of microseisms at different stations. Because it is difficult in practice to maintain the period of the vertical Galitzin at the theoretical value of 12 sec, a short-period seismograph has been adapted to serve the purpose. This "false Galitzin" has the characteristics of a 12-sec Galitzin instrument with a maximum amplification of 6.9 sec that is perfectly suited to the study of microseisms.

The constants of the instrument are given, and the components and their hook-up are described briefly. The optical amplification system is described in somewhat greater detail. With this instrument the amplification curve is known exactly, and its scale varies according to the amplitude of the microseisms (which follows the seasons) in such a way that the greater part of the records can be obtained without any adjustment of the seismograph. — D. B. V.

- 185-486. Jensen, Henry. Statistical studies on the IGY microseisms from København and Nord: [Denmark] *Geod. Inst. Medd.*, no. 39, 67 p., 1961.

This paper concerns microseisms of 3-8 sec period recorded at Copenhagen, Denmark, at Ivigtut, Scoresbysund, and Nord in Greenland. The different parameters of microseisms—amplitudes and periods, TN-TE differences, beat interval, and direction of approach—are discussed. Methods of determining direction of approach are described; that of the empty half-plane, used in this paper, is treated in some detail. This method is independent of the possible content of other than Rayleigh waves in the microseisms.

It is suggested that much more information could be collected if determination of direction of approach were included in the routine observations. To support this suggestion, statistical results of the use of directions at Copenhagen and at Nord are discussed. Most of the microseisms at Copenhagen reach the station from a northerly direction, but some of them come from the

southeast, mainly in the summer months and with a shorter period. Due to instrumental limitations, the Nord material is less homogeneous than that obtained at Copenhagen, and that at Scoresbysund is unsuitable for treatment. The prevailing direction at Nord is from the southwest across Greenland; some microseisms originate to the northwest, probably in the shelf waters north of Canada. Very few come from the southeast, from the center that accounts for the majority of microseisms recorded at Copenhagen, suggesting that this source area lies nearer the Norwegian shelf than to the East Greenland shelf; this is in accord with recent Norwegian and Russian results. — D. B. V.

- 185-487. Hatherton, T. Microseisms at Scott Base: Royal Astron. Soc. Geophys. Jour., v. 3, no. 4, p. 381-405, 1960.

The seasonal variation of the pack ice surrounding the Antarctic continent has a great effect on the levels of microseismic activity at Scott Base. Microseismic storms are in general of two types, one with periods 1-3.5 sec, the other with periods 4-10 sec. The short-period activity is due to events within the Ross Sea and is at a maximum during January and February when the Ross Sea is clear of ice. The long-period activity has a maximum during March and April and this is thought to be due to swell from peripheral cyclones penetrating the Ross Sea and creating microseisms after passing the continental shelf.

It is found that the microseisms of any period (T) have a limiting amplitude (A_{\max}) and that for the short-period microseisms $A_{\max} \propto T^{4.2}$ while for the long-period microseisms $A_{\max} \propto T^{6.0}$. The difference between these two relationships can be satisfactorily explained on the basis of frequency selective decay of the waves causing the long-period microseisms as these waves travel from the cyclone area to the continental shelf. The fourth-power relationship between maximum amplitude and period is similar to that obtained for single storms in America by Romney. It is suggested that this relationship might provide a useful test for a quantitative theory of microseisms, such as the standing wave theory, or alternatively that it can be used to investigate transmission and absorption processes in the crust.

The data appear to confirm the requirement of sea roughness for the generation of microseisms, the half-period relationship between microseisms and sea wave periods, and the role of the continental shelf and other crustal features as barriers to microseisms of periods less than $7\frac{1}{2}$ sec. — Author's summary

RADIOACTIVITY

- 185-488. National Bureau Standards. Redetermination of the half life of carbon-14: U.S. Natl. Bur. Standards Tech. News Bull., v. 45, no. 2, p. 21, 1961.

A more accurate value for the half life of carbon-14 is reported. The new value is 5,760 years with an overall probable error of 1 percent and is about 4 percent greater than the previously adopted value of 5,568 years. It is concluded that the spread in values obtained previously may have arisen from adsorption effects. — V. S. N.

- 185-489. Bauminger, E. R., and Cohen, S. G. Natural radioactivity of V^{50} and Ta^{180} : Phys. Rev., v. 110, no. 4, p. 953-957, 1958.

The methods of proportional counter and scintillation spectroscopy have been used to examine the possible radioactivity of the naturally occurring nuclides V^{50} and Ta^{180} . Some positive evidence is obtained that V^{50} decays by

K capture to the 1.58-Mev excited state for Ti^{50} with a half life of $(4.8 \pm 1.2) \times 10^{14}$ yr. A search for titanium K X-rays gave negative results. For Ta^{180} a lower limit of $(2.3 \pm 0.7) \times 10^{13}$ yr was found for the half life against decay by K capture and a lower limit of $(1.7 \pm 0.6) \times 10^{13}$ yr against beta decay. — Authors' abstract

185-490. Macfarlane, Ronald D. Natural occurrence of samarium-146: *Nature*, v. 188, no. 4757, p. 1180-1181, 1960.

Macfarlane and Kohman (in press) obtained a negative result in a search for Sm^{146} α -activity in natural samarium and set an upper limit of 0.01 disintegrations per g per sec for the specific activity in natural samarium. Recently, Vorob'yev and others (1959) reported an indication of the existence of natural Sm^{146} activity at a level they considered to be statistically insignificant, and established an upper limit of 0.3 disintegrations per g per sec for the specific activity. By increasing the sensitivity over these previous measurements (by counting a sample enriched in Sm^{146}), a limit of 0.003 disintegrations per g per sec is placed on the specific activity of samarium. Using a half-life value of 5×10^7 yr, the upper limit for the isotopic abundance of Sm^{146} in natural samarium is calculated as 2×10^{-7} percent.

Theoretical considerations, based on the recently rechecked value of 2.55 Mev for the α -particle energy of artificially produced Sm^{146} , favor an alpha half life of about 6×10^7 yr; if this is the correct half life, all primordial Sm^{146} should now be Nd^{142} . — D. B. V.

185-491. Parker, P. L., and Kuroda, P[aul] K. The occurrence of molybdenum-99 in natural and depleted uranium salts and the spontaneous fission half-life of uranium-238: *Jour. Inorg. Nucl. Chemistry*, v. 5, no. 3, p. 153-158, 1958.

Measurements of the Mo^{99}/U^{238} equilibrium ratios in aqueous solutions of nonirradiated uranium salts gave the following results: $(4.4 \pm 0.4) \times 10^{-4}$ and $(4.4 \pm 0.3) \times 10^{-4}$ disintegrations per sec of Mo^{99} per g U^{238} in natural and in depleted uranium, respectively. From this the spontaneous fission half life of U^{238} is calculated to be $(8.0 \pm 0.5) \times 10^{15}$ yr. — D. B. V.

185-492. Hamilton, E. The distribution of radioactivity in the major rock forming minerals: [Denmark] *Medd. om Grønland*, v. 182, no. 8, 41 p., 1960.

This is the same paper as that published in *Univ. Copenhagen Mus. Minéralogie Géologie, Commun. Géol.* No. 93, 35 p., 1959 (see *Geophys. Abs.* 181-410). — V. S. N.

185-493. Moraes, Marília Xavier de. Radioatividade de um monzonito da Foz do Douro (Porto) [Radioactivity of a monzonite from Foz do Douro (Porto)]: *Univ. Coimbra Mus. e Lab. Mineralog. Geol. Mem. e Notícias*, no. 48, p. 59-74, 1959.

The radioactivity of a monzonite from Foz do Douro, Portugal, was determined by means of nuclear emulsion plates. From this the uranium content was calculated to be 0.15×10^{-5} percent, which is about average for granitic rocks, and the thorium content was found to be 6.15×10^{-5} percent, which is somewhat higher than the average. The thorium is present almost entirely in zircon and its alteration product malacon, particularly the latter. The uranium is present in sphene, zircon, and malacon. — D. B. V.

- 185-494. Steinberg, Michel. Utilization de la mesure de la radioactivité naturelle des roches sédimentaires dans l'étude du Siderolithique du Poitou [Use of the measurement of the natural radioactivity of sedimentary rocks in the study of the Siderolithic of the Poitou]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 25, p. 3022-3024, 1960.

The natural β and γ radioactivity of sediments in the Poitiers and Bressuire quadrangles of the geologic map of France has been measured. The results show that different units within the Siderolithic of the Poitou region can be distinguished according to their radioactivity, and that the rocks of the Bressuire quadrangle are distinctly different from those of the Poitiers. The Siderolithic of the Bressuire quadrangle is actually a more or less reworked Cenomanian formation. The possibilities of using natural radioactivity as a stratigraphic correlation tool are demonstrated by these studies. — D. B. V.

- Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Significance of the argon-potassium ratio in ocean sediments. See Geophys. Abs. 185-590.

Mahadevan, C., Sastry, A. V. R., and Aswathanarayana, U. Some aspects of nuclear geology in India. See Geophys. Abs. 185-67.

- 185-495. Turner, R. C., Radley, J. M., and Mayneord, W. V. Naturally occurring alpha-activity of drinking waters: Nature, v. 189, no. 4762, p. 348-352, 1961.

The results of measurement of the natural alpha activity due to Ra^{226} in 71 drinking waters in Great Britain, together with values for short-lived Rn^{222} and Ra^{224} (ThX) where present, are tabulated. The highest values of long-lived alpha-activity are in spa waters. Next highest are those in waters from boreholes in strata other than chalk. Waters from chalk are still lower, and the least active are surface waters even though many are derived from areas of Precambrian or granitic rocks. — D. B. V.

- 185-496. Tóth, Árpád. Vízben oldott rádium- és radontartalom meghatározása torziós szálas elektrométerű emanométerrel [Determination of the amount of radium and radon dissolved in water with an emanometer on the principle of a torsion fiber electrometer (with German summary)]: Geofiz. Közlemények, v. 8, no. 4, p. 279-290, 1960.

A method and apparatus are described that can be used in the field for determining the dissolved radon content of water and in the laboratory for determining both radium and radon. The apparatus consists of an ionization chamber coupled to a torsion electrometer and a compensator. — D. B. V.

- Pandow, M., MacKay, C., and Wolfgang, R. The reaction of atomic carbon with oxygen: significance for the natural radiocarbon cycle. See Geophys. Abs. 185-381.

RADIOACTIVITY SURVEYING AND LOGGING

- 185-497. Balyasnyy, N. D., Boltneva, L. I., Dmitriyev, A. V., Ionov, V. A., and Nazarov, I. M. Opredeleniye soderzhanii radiya, toriya

i kaliya v gornykh porodakh s samoleta [Determination of the content of radium, thorium, and potassium in rocks with an airplane]: Atomnaya Energiya, v. 10, no. 6, p. 626-629, 1961.

Experimental investigations were made on the determination of radium, thorium, and potassium in rocks by the spectrum of gamma radiation measured from an airplane. A three channel radiometer was used which permits the measurements to be made in three energy areas of the spectrum with automatic compensation for background. The tests were made over an area 5.5X10 km which is underlain by sedimentary, igneous, and metamorphic rocks. The traverses were 100 m apart, and the flight altitude was 25 m.

The content of radium determined by the airborne method is 28 percent higher than that determined chemically, and that of thorium is 21 percent higher. No chemical analyses were made for comparison with the value for potassium; however, this value is in good agreement with values in the literature for these rocks. — J. W. C.

185-498. Van Wambeke, L. Contribution à l'étude de la minéralogie, de la géochémie, et des méthodes de prospection des carbonatites à pyrochlore au moyen des rayons X [Contribution to the study of the mineralogy, geochemistry, and methods of prospecting of pyrochlore-bearing carbonatites by means of X-rays]: Soc. Belge Géologie, Paléontologie, et Hydrologie Bull., v. 68, no. 2, p. 178-225, 1959.

The second part of this work deals with methods of prospecting for niobium deposits associated with carbonatites. The preliminary phase of exploration makes use of radioactive (scintillometer) and geochemical methods to discover primary or secondary anomalies that might correspond to pyrochlore-bearing carbonatite bodies. The extent and intensity of such an anomaly are then investigated by soil analyses. Because carbonatites often contain magnetite, ilmenite, or pyrrhotite, magnetic surveys can be used to advantage in this second phase. At Barreiro, Brazil, the internal structure of the deposit was revealed by a magnetic survey. — D. B. V.

185-499. Christman, David R. Counting soft betas: Nucleonics, v. 19, no. 5, p. 51-55, 64, 1961.

Factors to be considered in choosing a method for counting soft betas of C^{14} , S^{35} , and tritium are discussed. Each of these nuclides can be measured as a solid, liquid, or gas. The precision, sensitivity, intensity limits, and approximate cost of the nonflow counting methods are compared. With each method some counting problem arises that cannot be solved directly without one of the other methods. The bibliography contains 57 references. — J. W. C.

185-500. Kent, R. A. R. Scintillation alpha detection probes: Richland, Washington, General Electric Co., Hanford Plutonium Works, U. S. Atomic Energy Commission Research and Development Rept. HW 66837, 23 p. 1960.

Large and small area alpha survey probes employing photomultiplier tubes and scintillation detectors have been developed. These probes have a uniform alpha detection efficiency over the active screen area and are unaffected by operation in 4.5 r/hr gamma fields. — Author's abstract

- 185-501. Berbezier, J. Quelques appareils récents utilisés pour la recherche et l'étude des minerais radioactifs [Some new devices used for the investigation and study of radioactive ores]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 44-47, 1960.

Brief descriptions with photographs are given of an ultraviolet lamp, a direct current potentiometer, a solar battery, and an apparatus for measuring directly the thorium content of uranium-thorium minerals, all of which can be used in addition to the familiar Geiger-Müller or scintillation counters for prospecting or appraisal of radioactive ore deposits. — D. B. V.

- 185-502. Ligneris, X. des, and Bernazeaud, J[acques]. Le gisement de Mounana (Gabon) [The Mounana deposit (Gabon)]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 4-19, 1960.

The geographic and geologic setting, methods of prospecting and development, mining operations, present knowledge of the deposit, development program, and technical and personnel problems concerning the Mounana uranium deposit in Gabon, French Equatorial Africa, are summarized. This deposit was discovered in 1956 in the course of a detailed carborne scintillometer survey of the region. Systematic radiometric and geochemical prospecting of the anomaly involved a closely spaced network of measurements (10 m, sometimes 1 m station density), together with diamond drilling, to outline the form of the ore body. Geologic control during operations included radioactivity measurements in the mine tunnels and logging of hammer-drill holes. — D. B. V.

- 185-503. Théréné, Pierre, and Bigotte, Georges. La prospection des substances radioactives en Afrique par le Commissariat [The prospecting for radioactive substances in Africa by the Commissariat]: [France] Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 48-53, 1960.

This is a review of the radioactive mineral exploration program now in progress in French Africa. Airplanes are used for reconnaissance scintillometer surveys and for transport of ground parties; in the Sahara use of the helicopter permits immediate exploration up to the sampling stage of any interesting anomaly. Carborne scintillometers are used in suitable terrain in the Sahara. Various geochemical methods are used for more detailed study of anomalies. — D. B. V.

- 185-504. Reeve, W. H. Radiometric survey, Northern Province: Northern Rhodesia Geol. Survey Recs. for 1958, p. 26, 1960.

Approximately 2,400 miles of roads and tracks in the Northern Province, Northern Rhodesia, were traversed in September 1958 with a carborne scintillometer. Most of the routes were over rocks of the Plateau Series, and the radiometric profiles obtained are relatively uniform with a notable absence of marked anomalies. In one locality only does the anomaly exceed three times background; this is where large masses of granite crop out close to the road. — V. S. N.

- 185-505. O'Brien, P. L. A. Report on a car-borne scintillometer survey of the Gwembe Valley: Northern Rhodesia Geol. Survey Recs. for 1958, p. 27-28, 1960.

A carborne scintillometer survey was made in July 1958 covering an area of 3,200 sq mi, from Chirundu in the northeast to lat 17°45' S. and long 27° E., Northern Rhodesia. The primary object was to find any radioactivity connected with the Karroo and post-Karroo faulting in the Gwembe Valley. One of the most noticeable features of the survey was the almost complete lack of any radioactivity connected with the major Karroo faulting with the possible exception of the Bunga Hill fault block.

Two main areas of anomalies were recorded: the Munyumbwe area with 6 and the Bunga Hill area with 5; one isolated anomaly occurs in the Sigongo area. In the Bunga Hill area the 5 anomalies are in an area of 100 sq mi and surround the Bunga Hill fault block; they are by far the strongest in the Gwembe Valley.

Without exception all anomalies appear to occur in the lower beds of the Karroo Escarpment grit. Radiometric analysis showed that the radioactivity is due to uranium and thorium contained in goethite, which forms the ferruginous cementing material of the grit. Further investigation is recommended. — V.S.N.

- 185-506. Schoeneich, Krzysztof. Radiogeologiczne metody rozpoznawania z powierzchni nieciągłości tektonicznych nad nie rozciętymi złożami kopaliny [Radiogeological methods of surficial detection of tectonic discontinuities over unfaulted mineral deposits]: *Przegląd Geol.*, v. 8, no. 12, p. 649-651, 1960.

Radiogeologic methods are particularly useful in detecting faults within horizontal sediments that are overlain by thin Quaternary deposits. An emanometer of the type used in exploration for radioactive minerals was used to locate such faulting in the phosphorite at Annopol on the Vistula River. — J. W. C.

- 185-507. Babynets', A. E. [Babinets, A. Ye.], and Zvol'skiy [Zvol'skiy], S. T. Rezul'taty vykorystannya metodu rozsiyanykh neytroniv i hamma-promeniiv pry vyochenni rezhymu volohesti i shchil'nosti gruntiv [Results of the use of the method of scattered neutrons and gamma-rays in the study of the regime of the moisture content and compaction of soils (with Russian summary)]: *Akad. Nauk Ukrain. RSR Heol. Zhur.*, v. 20, no. 4, p. 45-53, 1960.

The successful use of radioactive isotopes to trace ground water migration and to study the compaction and moisture content of the ground near Kiev and Odessa in the Ukrainian S. S. R., in connection with landslip and hydrogeologic investigations, is described. — D. B. V.

- 185-508. Sano, Shun'ichi. Distribution of radioactivity of granitic rocks in the Takanawa Peninsula, Ehime Prefecture by car-borne radiometric survey (in Japanese with English abstract): *Japan Geol. Survey Bull.*, v. 11, no. 6, p. 369-384, 1960.

A carborne radiometric survey was made to study the distribution of radioactivity in the granitic rocks of the Takanawa Peninsula, Ehime Prefecture, Japan. The maintenance of the equipment and the dynamic character of the special ratemeter system used in the survey are discussed. The biotite granite and hornblende-biotite granite were found to be the most radioactive. The effect of weathering on the radioactivity of the rocks and the geometric effect in the measurement of the gamma-ray intensity are also discussed. — V.S.N.

- 185-509. Kiyoshima, Nobuyuki, and Shimodaira, Fumio. A radiometric survey at the western part of the Ube district, Yamaguchi Prefecture (in Japanese with English abstract): Japan Geol. Survey Bull., v. 11, no. 6, p. 385-389, 1960.

A radioactivity survey of the western part of the Ube district, Yamaguchi Prefecture, Japan, located a radioactive anomaly of 5 times the natural count in part of the Eiwa mine, a wolframite-bearing quartz vein deposit. Chemical analyses show that the uranium content of this area is generally between 0.002 and 0.009 percent. — V.S.N.

Agocs, W[illiam] B., Paton, J. R., and Alexander, J. B. Airborne magnetometer and scintillation counter survey over parts of Johore and Malacca (Area 5). See Geophys. Abs. 185-482.

- 185-510. Grammakov, A. G., Ovchinnikov, A. K., Lyubavin, Yu. P., Ovchinnikov, V. M., and Sazonov, A. M. Vliyaniye veshchestvennogo sostava uranovykh rud na stsintillyatsionnyy spektr ikh γ -izlucheniya [Effect of composition of uranium ores on the scintillation spectrums of their γ -radiation]: Atomnaya Energiya, v. 10, no. 6, p. 624-625, 1961.

Quantitative interpretation of the results of gamma logging of uranium deposits must take into account the dependence of the energy composition of the radiation on the physical properties of the ore, characteristics of the logging instrument, the state of the borehole, and the drilling conditions. In this paper the results of an experimental study of the energy characteristics of the radiation of uranium ore are described. Differential spectrums of gamma radiation of ore in models show that the intensity of the radiation varies greatly, particularly in the area of small energies. This variation is dependent largely on the effective atomic number of the ore; as this number increases, the peaks on the differential spectrum curves decrease in height. The effect of the composition of the ore on the energy composition of the gamma radiation decreases sharply for energies above 300 Kev but can still be detected at energies on the order of 700 Kev. — J.W.C.

- 185-511. Schrader, C. D., and Stinner, R. J. Remote analysis of surfaces by neutron-gamma-ray inelastic scattering technique: Jour. Geophys. Research, v. 66, no. 6, p. 1951-1956, 1961.

The feasibility of applying neutron-gamma-ray inelastic scattering techniques to the remote chemical analysis of unknown materials has been studied. The spectrums of gamma-rays produced by neutrons in a large sandpile containing various known percentages of the elements O, Mg, Al, Si, and Fe have been measured. It was found that a 5 percent abundance of any of these elements could be determined quantitatively to a precision of better than 10 percent. The method, using fast gating and timing circuits to select only the gamma-rays originating unambiguously from the neutron inelastic scattering process, appears so promising that a miniature pulsed accelerator is now being tested and packaged. Applications to the analysis of the lunar surface, planetary atmospheres, and the earth's crust and mantle are discussed. — D.B.V.

- 185-512. Sano, Shun'ichi. A portable gamma ray logger and the estimation of grade and ore reserves in radioactive deposit with reference to the logging at Ouchi district, Miyagi Prefecture (in Japanese with English abstract): Japan Geol. Survey Bull., v. 11, no. 6, p. 337-356, 1960.

The variations of distribution of gamma-ray intensity in a drill hole with the length of the detector, the thickness of the radioactive bed, and the diameter of the hole are discussed. Using a portable gamma-ray logger with a scintillation detector of only 30 mm designed especially for prospecting in mountainous areas, a method was developed for estimating the thickness of a horizontal ore bed and the grade of ores from theoretical calculations utilizing a constant determined by experiments in the drill hole. It was found that the area between the counting rate curve and the base line on the radioactivity log is proportional to the product of the grade and thickness independent of the drill hole diameter and the logging speed. Thus, when the correct value of the thickness is given, ore reserves may be estimated easily and the mean grade calculated.

Results of gamma-ray and electric logging in four drill holes at Ouchi district are discussed. — V. S. N.

- 185-513. Scott, J. H., Dodd, P. H., Drouillard, R. F., and Mudra, R. J. Quantitative interpretation of gamma-ray logs: *Geophysics*, v. 26, no. 2, p. 182-191, 1961.

A quantitative method for determining the concentration of gamma-ray emitting elements in layered rocks penetrated by boreholes has been developed, based on the relationship $\bar{G}T = k \int_{-\infty}^{+\infty} I dz$, where \bar{G} is the mean concentration of a radioactive element by weight, T is the thickness of the layer containing the radioactive element, k is a proportionality constant, I is the intensity of the gamma-ray field at a point on the borehole axis, and z is the distance of this point from a reference point on the axis. This relationship has been confirmed both theoretically and empirically.

In application, the grade-thickness product of a mineralized zone intersected in the borehole is determined by multiplying the area under the gamma-ray log curve by a proportionality constant. The mean grade of the zone is determined by dividing the grade-thickness product by the zone thickness. Corrections applied for nonstandard conditions in the borehole reduce the data to equivalence with standard calibration conditions. Because the volume sampled in this logging method is significantly larger than that of core samples, the resulting data are more representative than data from chemically assayed core. — D. B. V.

- 185-514. Fabre, P. Pollutions radioactives dans les forages horizontaux exécutés au marteau perforateur [Radioactive contaminations in horizontal drillholes made with the hammer drill]: [France]Comm. Énergie Atomique Bull. Inf. Sci. Tech., no. 38, p. 20-26, 1960.

Interpretation of gamma-radiation measurements made in horizontal hammer-drill holes in uranium mines for ore evaluation purposes may be distorted by contamination due to the presence of radon or to factors such as irregular settling of drilling muds. The difficulty can be partially avoided by logging the hole at least 24 hr after it is opened, but the only way to determine the amount of contamination accurately is to make supplementary measurements, such as β -radiation measurements. If a β and γ sonde is used instead of the usual γ sonde, the $(\beta+\gamma)/\gamma$ ratio will reveal the degree of contamination whenever the results of γ -ray logging do not correspond to the geologic context. — D. B. V.

- 185-515. Holgate, M. M. A study of the microlog as a porosity datum for the neutron log in Swan Hills, Alberta: *Oil in Canada*, v. 13, no. 3, p. 22-27, 1960.

This is virtually the same paper as that published in Canadian Mining Metall. Bull., v. 53, no. 579, p. 502-506, 1960. (See Geophys. Abs. 182-460.)—V.S.N.

Walker, Terry. Simplified log interpretation. See Geophys. Abs. 185-203.

SEISMIC EXPLORATION

- 185-516. Sengbush, R. L., Lawrence, P. L., and McDonal, F[rank] J. Interpretation of synthetic seismograms: Geophysics, v. 26, no. 2, p. 138-157, 1961.

The fundamentals of synthetic seismograms are treated from the point of view of linear filter theory. A linear filter model of the seismic process in the earth is described in detail, and reflections from simple velocity layering are discussed. Depth-time correspondence between the earth and the related seismogram is also discussed, and some examples are given comparing field records and synthetic seismograms.

The treatment is descriptive rather than mathematical and emphasizes the qualitative and in some cases the quantitative usefulness of the model in interpreting field records. An appendix gives the pertinent steps and formulas for the mathematical treatment of the question. — D. B. V.

- 185-517. Aynard, C., Mitran, H., and Dhinin, R. Variation des vitesses en rapport avec l'âge en la lithologie. Application de la loi de Faust [Variation of velocities with respect to age in lithology. Application of Faust's law (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 30-45, 1961.

Faust's first law (see Geophys. Abs. 145-12825) is considered the best guide in classifying data concerning velocities and their correlation with lithology, even if locally other laws better fit observed values. Data from both conventional and continuous velocity logs and from some particularly reliable velocity profiles have been reexamined, and "Faust's coefficient" (the ratio of true velocity to the value resulting from Faust's law, according to the age and present depth of the formation) has been computed for a series of geological formations in the Sahara and in the Aquitanian basin of France. Four maps of the basin showing the Faust coefficients for the Oligocene, Eocene-Paleocene with and without Danian, and Upper Cretaceous exclusive of Danian, and a cross section showing the relation to lithology are given.

It is too soon to tell whether such studies can be carried out at the beginning of exploration of a basin on the data of only a few logged wells. In the Aquitanian basin, velocity profile data are in close agreement with those from wells for the Tertiary, but information on the Mesozoic is meager. In basins of the Sahara type interference by multiple reflections is a major drawback. On the other hand, the possibilities of combined use of reflection and refraction to define lateral velocity variations may not have been fully appreciated. — D. B. V.

- 185-518. Khuan, Khun-Dzy. Plane problem of kinematic seismics under the condition where the velocity $v=v(w)$ is a continuous-rupture function (in Chinese with Russian summary): Acta Geophysica Sinica, v. 7, no. 2, p. 136-151, 1958.

Under conditions where the velocity $v=v(w)$ is a continuous-rupture function, formulas for general solution of the traveltime curve of reflected waves of a multilayered medium can be expressed in parametric form. This paper de-

rives such formulas, by means of which the equations of the traveltime curves can be written quickly for multilayered mediums that have velocity boundaries with an arbitrary angle of dip. A method of plotting traveltime curves of refracted waves in similar geologic conditions is also examined. These equations can give a strictly point solution. — J. W. C.

- 185-519. World Oil. Vibratory seismic method is important breakthrough: World Oil, v. 152, no. 5, p. 85, 1961.

The vibratory seismic method permits full control of the signal loaded into the earth and allows use of several energy sources (slave hydraulic vibrators) simultaneously. The resultant received signal can be correlated against the signal introduced into the earth, thereby reducing or eliminating extraneous noise. — J. W. C.

- 185-520. Gurvich, I. I., and Dukach, D. Sh. O statisticheskome effekte grupirovaniya v seismorazvedke [On the statistical effect of grouping in seismic exploration]: Prikladnaya Geofizika, no. 22, p. 53-62, 1959.

Considering a group of geophones as an interference system, it was possible to improve the data recorded by the group by eliminating or smoothing down the background of regular and irregular interferences. The method used for the suppression of these interferences is based on the directional selectivity effect studied by Napalkov (see Geophys. Abs. 179-375) and on the statistical effect. This paper discusses the influence of different sensitivities of individual geophones comprising the system on the statistical effect of the group; direction selectivity is taken into account. It was determined that the statistical average of the signal received by a group of geophones depends but little on the degree of their sensitivities (amplitudes). Therefore, a group of geophones having sensitivities different by a factor of 1.5-1.6 can be formed without affecting the group sensitivity as a whole. — A. J. S.

- 185-521. Eventov, Ya. S. K voprosy o metodike obshchego geologicheskogo izucheniya zakrytykh rayonov [Problem of the method of general geological study of covered regions]: Geologiya Nefti i Gaza, no. 4, p. 32-41, 1959.

Where it is necessary to study in detail a region that is masked by a sedimentary cover, the work should proceed in the following sequence: (1) compilation of a geologic map of the sediments that are exposed at the surface by aerogeological surveys and a minimum of ground traverses; (2) seismic survey; (3) drilling of shallow boreholes along the seismic profiles—an area of 500 sq km should have 15-20 boreholes; (4) compilation of seismogeologic maps; and (5) compilation of a stratigraphic section on the basis of the drilling and seismic data. — J. W. C.

- 185-522. Richards, T. C. Motion of the ground on arrival of reflected longitudinal and transverse waves at wide-angle reflection distances: Geophysics, v. 26, no. 3, p. 277-297, 1961.

The horizontal and vertical motions of the surface of the ground on the arrival of reflected longitudinal and transverse waves from an elastic discontinuity are determined theoretically, with special reference to those parameters encountered in exploring for limestone structures in the foothills of Western Canada by wide-angle reflection techniques. The results, which cover a wide range of possible overburden velocities, are expressed by means of curves from

which the displacement for any practical elastic contrast, depth, and observation distance may be readily determined. Properties of these curves are examined empirically. The theory assumes plane waves in determining the amplitude ratios at the structural or free surface discontinuities and spherical waves in deriving spread factors. Corrections to the curves on account of a nonuniform overburden velocity are considered in the case of a typical central foothills well. The evidence for PP and PS in model, and to a less extent in field work and the significance of phase changes on reflection are discussed. It is concluded that the horizontal geophone should prove to be a useful additional tool in wide-angle reflection surveys in disturbed foothills zones. Here, it could confirm or refute the arrival of a reflection registered by the vertical geophones in the many cases where doubt exists. — Author's abstract

- 185-523. Boulware, Robert A. How to analyze reflection data in permafrost areas: *World Oil*, v. 152, no. 5, p. 80-84, 1961.

In seismic computations the presence or absence of permafrost, the thickness where present, and uncertainty of velocity cause problems in determination of depth to reflecting interfaces. The refraction technique normally cannot be applied to measure the depth of the frozen zone because the velocity of the underlying material is usually lower than that of the permafrost. In some places it is possible to obtain reflected energy from the base of the permafrost, and depth to this surface can then be determined if accurate velocity information within the permafrost is available. Where the velocity is uncertain, the depth to the interface can be determined by a series of formulas which take into account the shot point elevation, a reference surface near the shot elevation, and shot depth. — J. W. C.

- 185-524. Starodubrovskaya, S. P. Eksperimental'noye izucheniye osobennostey prodol'nykh voln, otrazhennykh ot tonkogo sloya. [Experimental study of peculiarities of longitudinal waves reflected from a thin layer]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1466-1473, 1960.

Special investigations were made of reflected waves corresponding to one horizontal thin layer of uniform thickness with a high velocity of propagation. The studies were made in the Carpathian forward downwarp in two areas of known seismogeological structure containing one horizontal thin high velocity layer, a gypsum-anhydrite horizon with $v=4,500-5,000$ m per sec. With varying depth of occurrence of the thin layer $h/\lambda_2=0.15$, $h/\lambda_1=0.3$ ($f_{pr}=50c$) and $v_1/v_2=0.5$ along the interval from $x=0$ to the nearest geophone, the following can be concluded: The wave reflected from a thin layer in both areas of investigation is dominant and can be correlated easily on the records. The dynamic features of the wave, the shape of the recorded wave, the duration of the oscillations, and predominant periods do not change with distance from the source of excitation. Averaged amplitudes gradually attenuate with distance. The waves recorded in areas with varying depths of occurrence of the thin layer have different predominant frequencies and different rates of attenuation of the amplitudes with distance. — J. W. C.

- 185-525. Michon, D. Phénomènes anormaux en sismique reflection [Abnormal phenomena in seismic reflection (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 19-29, 1961.

Abnormal phenomena such as refractions and diffractions are more clearly seen on corrected sections produced in magnetic processing offices than on

single reflection records, making their understanding increasingly important. This paper discusses the geometric properties pertaining to such phenomena and attempts to distinguish between what is useful for interpretation and what is not.

Diffractions and refractions that indicate faults and diffractions caused by irregularities of the boundary between heterogeneous mediums are treated. Classified as parasite phenomena are: (1) refractions following very shallow horizons, mainly related to topographic irregularities; (2) diffractions on the upward path caused by shallow faults; and (3) diffractions in the horizontal plane, encountered either in marine surveys or in the case of inclusions in otherwise homogeneous mediums. — D. B. V.

- 185-526. Laherrère, J. Utilization pratique des films synthétiques dans le Sahara Nord [Practical use of synthetic seismograms in the northern Sahara (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 46-59, 1961.

Nineteen synthetic seismograms compiled from data on 12 wells, field seismograms, and continuous velocity logs in the northern Sahara by different methods (by analogy and by computation) developed by 4 French companies are compared. Comparison with field records shows that best results are not always obtained with a synthetic seismogram including multiples. In the northern Sahara, however, where multiple reflections are of considerable importance and impossible to detect by velocity studies, and where interpretation is based primarily on continuity, the study of synthetic records including multiples on all exploratory wells would appear to be indispensable. — D. B. V.

- 185-527. Schriever, William. Reflection seismograph prospecting, how it started: *Shale Shaker*, v. 11, no. 7, p. 18-21, 1961.

The history of the development of seismic reflection prospecting from its inception in 1921 in Oklahoma until 1952 is reviewed. — V. S. N.

- 185-528. World Oil. Salt dome refraction survey aided by double-jug layout: *World Oil*, v. 152, no. 7, p. 106, 1961.

A widely used technique for mapping salt domes makes use of a geophone at the bottom of a drill hole. A modification of this method provides for a second geophone in the hole 500 or 1,000 feet above the first. Both geophones operate simultaneously. The difference in arrival time at the two geophones measures the angle at which the waves arrive at the well and hence identifies in elevation the points of entry into the salt dome. This method is particularly useful in offshore work for determining the configuration of overhangs in salt domes. — J. W. C.

- 185-529. Lavergne, M. Etude sur modèle ultrasonique du problème des couches minces en sismique refraction [Ultrasonic model study of the problem of thin layers in seismic refraction (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 1, p. 60-73, 1961.

Seismograms obtained by means of ultrasonic model techniques have led to some results concerning the properties of waves refracted along thin layers. Velocities have been determined as a function of layer thicknesses. When thickness is small compared to wave length, the velocities of refracted waves may be as much as 6 percent less than along thick layers; amplitude attenuation with distance is large, and depth determination from measurements of

delay times is unreliable. The experiments were made on two-dimensional models, but the results can be extended to three-dimensional cases. — D. B. V.

- 185-530. Behrens, Jörn. Refraktionsseismische Messungen auf See [Seismic refraction measurements at sea (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 4, p. 161-176, 1960.

A new method of marine refraction surveying is described. Geophones on the sea bottom are connected to a buoy which contains instruments for wireless communication of the measurements to the recording ship. Frequency modulation of low carrier frequencies is used. The results are recorded on magnetic tape in addition to the usual direct recording. The procedure is described and some preliminary results are discussed. — D. B. V.

- 185-531. Kilczer, Gyula. A rétegvastagság és mélység meghatározásának a kissebességű réteg elhanyagolásából eredő hibája szeizmikus refrakciós mérésnél [The errors in determinations of layer thickness and depth in seismic refraction measurements due to neglecting the weathered layer (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 197-200, 1960.

It is shown theoretically and illustrated by a numerical example that neglecting the weathered layer in seismic refraction calculations does not result in any significant error in the value obtained for depth and thickness of the deeper layers in a multilayered case. — D. B. V.

- 185-532. Kilczer, Gyula, and Elek, Ilona. Dombos terepen végzett szeizmikus refrakciós mérések javítása [Correction for seismic refraction measurements made in hilly terrain (with German summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 201-207, 1960.

First arrivals in a seismic profile are delayed in crossing a hill, producing a "hump" in the velocity branches of the travelttime curve. A simple correction method is described, by means of which the average seismic velocity of the hill can be calculated without special measurements, using the area of the hump (measured with a planimeter) and the cross section of the hill. The method is illustrated by a practical example. — D. B. V.

- 185-533. Szénás, György. A szeizmikus módszer kifejlődésének és alkalmazásának egyes kérdései [Some problems of the development and application of the seismic method (with German and English summaries)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 255-278, 1960.

Use of the refraction method is increasing today because in many areas, mainly sedimentary basins, the reflection method does not yield sufficient information. This revival implies further development as a result of analysis of the so-called "later arrivals." — Author's German summary, D. B. V.

- 185-534. Sarmiento, Roberto. Geological factors influencing porosity estimates from velocity logs: *Am. Assoc. Petroleum Geologists Bull.*, v. 45, no. 5, p. 633-644, 1961.

The close relation between acoustic velocity and porosity makes it possible to use velocity logs to determine porosity. However, velocity also depends on other geologic factors which, if known, permit more accurate log interpretation. In sandstones these factors are age, composition, depth, compaction, shaliness, and nature of pore fluid; of these, depth and shaliness are most

important. Equations based on statistical computation of traveltime-porosity relations that take these variables into account give more accurate porosity estimates than the widely-used time-average equation.

In carbonate rocks velocities are less affected by depth, but mineralogic composition and the presence of vugs are more important. Statistical traveltime-porosity equations computed for Paleozoic limestones and dolomites are closer to the time-averaged model than are the sandstone relations. — D. B. V.

- 185-535. Neyshadt, N. M. Poiski pegmatitov pri pomoshchi seismoelektricheskogo effekta vtorogo roda [Exploration of pegmatites by means of the seismoelectric effect of the second variety]: *Soviet-skaya Geologiya*, no. 1, p. 121-127, 1961.

The seismoelectric effect of the second variety includes all phenomena of natural electrical potential arising in rocks under the action of elastic vibrations or static pressure, independently of the nature of these phenomena. Experiments in the use of this effect in exploration for pegmatites were made in the Kola Peninsula. The pegmatites investigated could not be distinguished by seismic or electrical observations. Profiles of the seismoelectric effect, however, reflected the presence of the pegmatites very sharply. — J. W. C.

- 185-536. Tullos, F. N., and Cummings, L. C., Jr. An analog seismic correlator: *Geophysics*, v. 26, no. 3, p. 298-308, 1961.

An analog computer has been built to compute the cross-correlation coefficients of multitrace seismograms. The evaluation program has shown that the computer has greater accuracy than is normally required to compute the cross-correlation functions of short samples of data. Points on the correlation curves are computed and plotted at the rate of approximately 50 points per minute. Scanning is in difference of arrival times (Δt) across the record, with increments of $\frac{1}{2}$ to 16 millisecond. The correlation process is completely automatic with the exception of normalization, which is approximated by holding the total average signal power constant with a ganged attenuator. Analysis of synthetic and actual seismic data indicates that the correlation will be an interpretational aid in areas where the data are poor. — Authors' abstract

- 185-537. Officer, Charles B. The Gas Exploder, Sparker and Harru: *Offshore*, v. 14, no. 4, p. 19-21, 1961.

Three systems for geophysical exploration in water-covered areas, introduced within the past three years, are described. They are the continuous seismic profilers, the Gas Exploder and the Sparker, and a precision radar location system, the Harru. The Gas Exploder and Sparker differ primarily in their sound source; the former uses an explosive mixture of propane and oxygen detonated in an open chamber beneath the water, and the latter uses the underwater detonation of a 12,000 v spark. The Harru gives offshore locations by two accurate radar ranges monitored continuously from two known targets. The survey boat's location is plotted automatically. — V. S. N.

- 185-538. McDonal, F[rank] J. New marine seismic system: *Offshore*, v. 14, no. 4, p. 23-25, 1961.

A marine seismic system for surveying over water-covered areas is described. The seismic source is provided by the underwater explosion of a mixture of propane and air, or propane, air, and oxygen. This is essentially the same system as that used in the Gas Exploder (see *Geophys. Abs.* 185-537). — V. S. N.

- 185-539. Fritz, Axel M. The MD engineering seismograph and its application to highway engineering, in 11th Annual Symposium on Highway Engineering Geology Proceedings: Florida Geol. Survey, p. 55-65, 1960.

The MD seismograph, which measures the traveltime for the fastest wave whatever its path, has widespread application in highway engineering. The types of subsurface problems that can be solved are described, the principles of operation are explained, and some examples of application to highway construction are given. — V.S.N.

- 185-540. Moss, John H., and Bonini, William E. Seismic evidence supporting a new interpretation of the Cody terrace near Cody, Wyoming: Geol. Soc. America Bull., v. 72, no. 4, p. 547-556, 1961.

Seismic studies suggest that the Cody terrace complex bordering the Shoshone River near Cody, Wyo., is an alluvial terrace, not a rock-cut terrace as previously proposed. The results underscore the usefulness of seismic studies in geomorphic work. — D.B.V.

- 185-541. Berg, Joseph W., Jr., Cook, Kenneth L., Narans, Harry D., Jr., and Leamer, Richard J. Seismic profiles in northwestern Utah: Pilot Range and Grouse Creek Range area: Jour. Geophys. Research, v. 66, no. 4, p. 1255-1263, 1961.

Two seismic refraction profiles, 55 and 95 km long, were established in the area between Wendover and Grouse Creek in northwestern Utah. The two profiles were reversed for about 47 km of the distance. Commercial seismic prospecting equipment, modified to pass frequencies between about 3 and 50 cycles per second, was used. Results show that materials having velocities of about 2.0, 5.5, 6.2, and 7.4(?) km/s exist at depths of about 0, 0.8, 4, and 24 km, respectively. The apparent dips of the 5.5- and 6.2-km/s horizons are about $\frac{1}{4}^{\circ}$ N. and $2\frac{1}{2}^{\circ}$ N., respectively. Reflections from the 24-km horizon were identified on seismograms taken at 5 locations; a second reflection, which could result from a reflecting horizon at a depth of about 27 km, was identified on 4 of the 5 seismograms. — D.B.V.

- 185-542. Paterson, Norman R., and Gregotski, Edward L. Application of underwater profiler (Sparker) to geophysical exploration under Lake Erie: Oil in Canada, v. 13, no. 19, p. 24-27, 1961.

In 1958 and 1959 an underwater seismic survey using the Sparker underwater profiler was made on Lake Erie offshore from the Tilbury gas field. Results show that (1) bottom and bedrock surfaces can nearly always be accurately mapped; (2) at least one sub-bedrock geological horizon can be mapped continuously in more than half the areas traversed; (3) where no continuous sub-bedrock reflection exists, events can be followed locally; and (4) faults are easily detected. The lack of good, continuous reflections from deeper geological horizons (500-1,000 feet) is due mainly to lack of elastic property contrast; more powerful equipment, such as the Gas Exploder, may provide improvement. — V.S.N.

- 185-543. Shor, George G., [Jr.], and Fisher, Robert L. Middle America Trench: Seismic-refraction studies: Geol. Soc. America Bull., v. 72, no. 5, p. 721-730, 1961.

Seismic-refraction profiles in the Middle America Trench show that the main crustal layer ranges from normal oceanic thickness (about 5 km) to half again as thick. Sediments are thicker than in the Pacific Basin. Because of the increased depth of water and sediment at all stations and thickening of the main crustal layer at some stations, the M-discontinuity bows down beneath the trench. At the outer edge of the continental shelf near Guatemala, the water is replaced by sediments and rock which may be either consolidated sediments or volcanic rocks; the M-discontinuity is at little greater depth than beneath the trench. — Authors' abstract

Fisher, Robert L. Middle America Trench: Topography and structure. See Geophys. Abs. 185-588.

Shurbet, D. H. Determination of sedimentary thickness in the Mexican geosyncline by Rayleigh wave dispersion. See Geophys. Abs. 185-142.

185-544. Evrard, Pierre. Sismique [Seismic surveys]: Mus. Royal Congo Belge Annales, Ser. 8, Sci. Géol., v. 33, 88 p., 1960.

This is a report on seismic surveys made in the Congo Basin between 1952 and 1956. Both reflection and refraction methods were used. The organization of the three expeditions and methods of operation and interpretation are described. Detailed results are presented in tables and profiles.

The maximum thickness of the cover (Mesozoic and younger) was found to be 1,200 m. The finding of sedimentary formations in the basement that are older than the Lower Permian-Upper Carboniferous Lukuga Series, several thousand meters thick, subsiding, and relatively shallow poses several new problems in the geologic study of the area. — D. B. V.

Tryggvason, Eysteinn, and Báth, Markus. Upper crustal structure of Iceland. See Geophys. Abs. 185-351.

185-545. Maries, A. C., and Beckmann, W[alter] C. A new geophysical method for the exploration of undersea coalfields: Mining Engineer, no. 4, p. 262-274, 1961; Inst. Mining Engineers Trans. 1960-61, v. 120, Paper no. 3847, 1961.

The equipment and techniques of operation used in a seismic reflection survey of undersea coalfields off the Northumberland and Durham coast, the Cumberland coast, and in Firth of Forth, England, are described. The Sparker method was used. More than 2,000 miles of traverses were made covering 400 sq mi at the cost of one moderately deep borehole on land or $\frac{1}{2}$ the cost of an offshore borehole. The depth of penetration was sufficient to show depth to the sea floor, depth to bedrock below unconsolidated sediments, inclination of the uppermost bedrock, and the presence of faults, igneous intrusions, and submarine outcrops. — V. S. N.

185-546. Millouet, J. Problèmes posés à la sismique dans la région parisienne [Problems facing seismic surveying in the Paris region (with English abstract)]: Geophys. Prosp., v. 9, no. 1, p. 1-18, 1961.

Two major difficulties in seismic surveying in the Paris area are: The presence of high-velocity silicified limestone beds that are hard to drill make it difficult to obtain surface corrections and carry strong ground roll; and slight structural variations call for very accurate time control. The drilling difficulties and the need to eliminate parasite waves have led to the adoption of

pattern shooting from hammer-drill holes. Shooting with a lateral offset of 600 m has eliminated groundroll effectively enough to permit work in regions where formerly no reflections could be obtained. Surface corrections are obtained by means of uphole velocity surveys in deep holes at particularly important points, and at other points by calculation from structural maps of surface strata or from velocity-depth curves.

Determination of lateral velocity variations by surface velocity shooting is not feasible in this part of the Paris basin. The control of reflection times must take into account the deformation of the signal as a function of the type of recording equipment and filters used, and also the modification of the character of the reflection due to lateral stratigraphic variations. These variations can be observed by comparing the different velocity logs. — D. B. V.

- 185-547. Carron, Jean-Paul, and Nozières, Philippe. Les variations du bruit de fond sismique dans le bassin parisien [The variations of seismic background noise in the Paris basin]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 25, p. 3019-3021, 1960.

The effect of the nature of the ground on the amplitude of seismic background noise (of the order of 1 cycle per second frequency) was investigated using the records of 18 stations in the Paris basin. A very clear correlation was found between amplitude of the noise and thickness of the sediments overlying the Permian. These results cannot be explained in any simple fashion, but a relation to settling and compaction of young sediments is suggested. — D. B. V.

- 185-548. Vallon, Michel. Épaisseur du glacier du Tacul (massif du Mont-Blanc) [Thickness of the Tacul glacier (Mont Blanc massif)]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 12, p. 1815-1817, 1961.

The results of a seismic reflection survey made in 1960 on the Tacul glacier on the Mont Blanc massif in the Alps are presented in two maps, one showing the plan of seismic operations and the other the bedrock configuration. The valley is U-shaped in transverse profile and shows two steps in longitudinal profile. Maximum ice thickness is slightly more than 400 m. — D. B. V.

- 185-549. Drake, C[harles] L., Gaibar-Puertas, C., Nafe, J[ohn] E., and Lanseth, M. Estudios de prospección sísmica por refracción en el Golfo de Cádiz [Seismic refraction prospecting studies in the Gulf of Cádiz (with English abstract)]: Rev. Geofísica, v. 18, no. 70, p. 143-162, 1959.

Six refraction profiles surveyed in the Gulf of Cádiz, Spain, in the summer of 1956 showed four distinct units with mean longitudinal wave velocities of 1.85, 2.37, 3.67, and 5.64 kmps. These correspond, respectively, with Pliocene-Miocene sediments, Upper Mesozoic limestones, the Triassic (almost entirely Keuper marl), and a Variscan basement.

Structural contour and isopach maps are drawn on these units, and their relations to regional geology are inferred. The propagation of sound in the water-sediment system is also discussed. — D. B. V.

- 185-550. Seelis, Karl-Heinz. Das reflexionsseismische Bild des Bentheimer Sandsteines im Raum von Meppen [The seismic reflection picture of the Benthem sandstone in the Meppen area]: Erdöl u. Kohle, v. 12, no. 12, p. 953-957, 1959.

Disturbing reflections in seismograms obtained in the Hebelermeer oil concession near Meppen on the Ems, Germany, were suppressed by using unequal charges (12 shotholes in a special pattern, with stronger charges in central holes) and by opening the filter wide, especially to the high frequencies. The records thus obtained showed very clear reflections that could be correlated according to the character of their vibration features. In particular, the abrupt negative change of velocity at the base of the Bentheim sandstone and the resulting "negative" reflection were used to identify that horizon and trace its decrease in thickness. — D. B. V.

- 185-551. Janetsky, Donald. Refraktionsseismische Untersuchungen am Abbruch von Wittenberg [Seismic refraction investigations on the Wittenberg fault (with English and Russian summaries)]: *Zeitschr. Angew. Geologie*, v. 6, no. 4, p. 170-172, 1960.

Reconnaissance refraction surveys north and northeast of Zerbst in East Germany showed a concentration of isochrones trending in a northwest-southeast ("flat Hercynian") direction, reflecting a sharp change in velocity on the Wittenberg fault. A profile across the fault showed that the cause of this change is not a thickening of the Cenozoic, but must be attributed to differences in velocity at the upper surface of the pre-Tertiary. Three distinctly different velocities appeared in the south, central, and north sections of the profile; these are, respectively, 4.8 km/s, interpreted as Paleozoic (Carboniferous and Zechstein), 3.6 km/s, Mesozoic (Buntsandstein?), and 2.7 km/s, younger Mesozoic (Upper Cretaceous?). Borings showed the three different formations underlying the Cenozoic. — D. B. V.

- 185-552. Gálfi, János, and Pálos, Miklós. Refrakciós kéregkutató szelvény a Magyar Medencében [Crustal-study refraction profile in the Hungarian Basin (with English abstract)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 177-187, 1960.

A 120-km refraction profile was established in the eastern part of the Great Hungarian Plain between Hajdúszoboszló and Törtel. Good arrivals were obtained from the surface of the granitic layer and weaker ones from the M-discontinuity. Average thicknesses are calculated as follows: depth to granitic layer, 2.47 km; thickness of granitic layer, 11.13 km; thickness of gabbroic layer, 4.77 km; and total thickness, 22.22 km. There is a regional dip from Hajdúszoboszló to Törtel. — D. B. V.

- 185-553. Gálfi, János, and Stegena, Lajos. Mélységi reflexiók és a földkéreg szerkezete a Magyar Medencében [Deep reflections and crustal structure in the Hungarian Basin (with English summary)]: *Geofiz. Közlemények*, v. 8, no. 4, p. 189-195, 1960.

The results of earlier and recent seismic reflection investigations in Hungary indicate a crustal thickness of 24 km; the gabbro layer averages 4-5 km. Along an east-west profile, the crust thickens toward the center of the Great Hungarian Plain. The reflection results agree well with those calculated from refraction measurements and earthquake data. — D. B. V.

- 185-554. Miynarski, Stefan. Prace sejsmiczne na Niżu Polskim [Seismic work in the Polish Lowland]: *Przegląd Geol.*, v. 9, no. 1, p. 34-36, 1961.

The development of seismic surveying in the Polish Lowland is described, and examples are given of the changes in methods over the years. — J. W. C.

- 185-555. Kharechko, G. E. Do pytannya pro tektoniku Rus'koy platformy v rayonі mist Berdyans'k-Nohays'k (za danymy heofizychnykh doslidzhen') [On the problem of the structure of the Russian platform in the area of the cities Berdyansk and Nogaysk (according to the data of geophysical investigations)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 20, no. 1, p. 73-81, 1960.

The basement relief and structure in the vicinity of Berdyansk (Osipenko) and Nogaysk on the Sea of Azov have been determined seismically. Results are given in graphs, two profiles (along the Berdyanska and Obitochna Peninsulas), and a sketch map that shows basement contours, major faults, and areas of positive and negative gravity field. The crystalline basement slopes southward under the sea, roughly parallel to the overlying sedimentary cover but broken by faults. — D. B. V.

- 185-556. Sollogub, V. B., Lossovskiy, Ye. K., Khilins'kiy, L. A., Sokolov, B. K., and Nikiforuk, B. S. Dosvid zastosuvannya visokochotnoyi seysmorozvidki z metoyu rozchlenuvannya metamorfichnogo kompleksu porid Bilozers'koho zalizorudnogo rodovishcha [Experience in the use of high-frequency seismic surveys for the purpose of differentiating metamorphic rock complexes of the Belozerskiy iron deposits (with Russian and English summaries)]: Akad. Nauk Ukrayin. RSR Dopovidī, no. 1, p. 16-21, 1961.

High-frequency seismic surveying was used to differentiate the metamorphic rocks of the Belozerskiy iron deposits of the Ukraine S. S. R. These rocks dip vertically and are covered by 250-400 m of sedimentary rocks. Not only is differentiation possible, but also ore zones can be recognized. The effect of defocusing the energy by curvilinear refracting boundaries is taken into account in distinguishing the ore zones. — J. W. C.

- Neprochnov, Yu. N., Goncharov, V. P., and Neprochnova, A. F. Seismic data on crustal structure in the central part of the Black Sea. See Geophys. Abs. 185-357.

- 185-557. Yelanskiy, L. N., and Tolkachev, M. I. Nekotoryye voprosy geologii yugo-vostoka Kuybyshevskogo Zavolzh'ya [Some problems of the geology of the southeast of the Kuybyshev Trans-Volga region]: Geologiya Nefti i Gaza, no. 5, p. 44-49, 1959.

The problem of distinguishing the terrigenous unit of the Lower Carboniferous in the Kuybyshev Trans-Volga region is treated, and a map of the distribution of this unit, based on seismic survey and drilling, is presented. Reflections could be recorded from the base of the unit only where its thickness is greater than 75-100 m. The seismic surveys confirm earlier magnetic and gravity surveys as to the distribution of projections on the basement surface. — J. W. C.

- Balavadze, B. K., and Tvaltvadze, G[uri] K. Crustal structure of the Transcaucasian-Caspian depression according to geophysical data. See Geophys. Abs. 185-324.

- 185-558. Veytsman, P. S., Gal'perin, Ye. I., Zverev, S. M., Kosminskaya, I. P., Krakshina, R. M., Mikhota, G. G., and Tulina, Yu. V. Nekotoryye rezul'taty izucheniya stroyeniya zemnoy kory v oblasti Kuril'skoy ostrovnnoy dugi i prilegayushchikh uchastkov Tikhogo

okeana po dannym glubinnogo seymicheskogo sondirovaniya [Some results of investigation of crustal structure in the region of the Kurile Island Arc and adjacent parts of the Pacific Ocean according to seismic depth sounding data]: Akad. Nauk SSSR Izv. Ser. Geol., no. 1, p. 81-86, 1961.

According to the data of seismic depth sounding, the crustal structure in the Kurile Island Arc and adjacent parts of the Pacific Ocean is complex. The zone between the islands and the deep Kurile-Kamchatka trench is not a structural unit. The northern section is completely continental and the southern section is partly continental, and these parts are related to the continental structures of the Kamchatka Peninsula and Japanese islands. The central section is of intermediate type, apparently the extension of the deep part of the Sea of Okhotsk.

These results agree with gravimetric data. The sea bottom topography, development of volcanism, seismicity, and recent movements also reflect this threefold division. — D. B. V.

185-559. Central Water and Power Research Station Poona. Geophysical investigations at Mohana dam site: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona Ann. Research Mem., p. 64-66, 1959.

Seismic refraction and electrical resistivity surveys were made at the site of the proposed dam on the Mohana River, northwest of Itkhor, Hazaribagh district, Bihar State, India, to assess the depth of the overburden. Sixty depth estimates were made and on the basis of the bedrock structures determined from these estimates, a new dam site was proposed. The new site is shorter than the original site and approximately at right angles to the trend of the structures. — V. S. N.

185-560. Central Water and Power Research Station Poona. Geophysical investigations along surplus channel, Gudari dam site, Vamsadhara project: India Ministry of Irrigation and Power, Central Water and Power Research Sta. Poona Ann. Research Mem., p. 69-70, 1959.

A seismic refraction survey was made of the spillway section and along the surplus channel of the proposed Gudari dam across the Vamsadhara River, India, to determine depths to bedrock. Large acoustic contrasts between the bedrock and the overburden made interpretation easy; it was found that the bedrock dips steeply near the spillway section and gently along the surplus channel. Bedrock velocities were from 16,000 fps to 18,000 fps, and from these the formation was identified as a metamorphosed variety of the sediments (Khondalite) exposed on the two dam abutments. — V. S. N.

185-561. Khuan, Khun-Dzy. Seismo-geologic characteristics of the Dzhungar depression (in Chinese with Russian summary): Acta Geophys. Sinica, v. 7, no. 2, p. 116-135, 1958.

Large-scale seismic surveys, made in 1952-57 in the entire Dzhungar depression in Sinkiang province, yielded provisional ideas on the seismo-geology of the area. The methods of operations are described briefly, and several examples of seismograms are reproduced. Research is to be directed toward methods of study of gentle structures, ways to eliminate interference, and methods of operations in areas of barchans. — J. W. C.

- 185-562. Tseng, Yung-sheng, K'an, Yung-shu, and Ho, Ch'uan-ta. Low frequency seismic work in Tsaidam Basin [in Chinese]: K'o-hsueh T'ung-pao [Scientia], no. 10, p. 313-316, 1960. Translation by U.S. Dept. Commerce, Office Tech. Services, JPRS 5706, 16 p., 1960.

In the summer of 1958 an experimental low frequency seismic survey of the Tsaidam Basin, Tsinghai, China, was undertaken to determine the depth to the basement and the major boundaries of the overlying Paleozoic sedimentary series. Medium frequency seismic surveys are not successful in this area because in parts of the basin the Paleozoic limestones and metamorphic rocks exhibit very high elastic wave velocities that produce a screening effect and prevent successful mapping of the basement. Using the low frequency method, boundaries at depths of more than 10 km were determined. The instruments and techniques used are described, and the complex characteristics of the low frequency seismic waves obtained are discussed. — V.S.N.

- 185-563. Sasa, Yasuo, and Izaki, Akira. Analysis and geologic interpretation of sonic survey on the western passage of Tsugaru Strait, Japan (1) (in Japanese with English abstract): Jour. Geography [Tokyo] v. 70, no. 1, p. 3-18, 1961.

The results of a sonic survey in which a continuous seismic profiler (Sparker) was used to determine the geology underlying Tsugaru Strait between Hokkaido and Honshu, Japan, are discussed. Methods used to analyze the sonic data are presented, and the geologic interpretations of the data are shown in cross sections. — V.S.N.

- Zverev, S. M. On the structure of the sedimentary layer of some parts of the Pacific Ocean according to seismic reflection data. See Geophys. Abs. 185-589.

- 185-564. Crary, A. P. Marine-sediment thickness in the eastern Ross Sea area, Antarctica: Geol. Soc. America Bull., v. 72, no. 5, p. 787-790, 1961.

Ocean sediment thicknesses were obtained at two locations in the eastern Ross Sea during the International Geophysical Year by seismic refraction and reflection methods. At the Little America station the sediment thickness is about 1,325 m, and at site 49, about 35 km to the southeast on an inland traverse, about 754 m; depths to bedrock are about 1,953 and 1,354 m, respectively. Most of the sediment may have been deposited by ice. — D.B.V.

- 185-565. Thiel, Edward. Antarctica, one continent or two?: Polar Rec., v. 10, no. 67, p. 335-348, 1961.

The Antarctic continent crudely resembles a pear. The top of the pear, which includes the Palmer Peninsula, the Ross Ice Shelf, the Filchner Ice Shelf, and the intervening grounded ice area of Marie Byrd Land and Ellsworth Highland, may be designated as "Lesser Antarctica." "Greater Antarctica" is the bottom of the pear and includes the greater part of the continent, largely high plateau. The demarcation line lies on the Pacific Ocean side of mountains that extend across the continent from Cape Adare to Coats Land. Three field seasons of geophysical traverse activity in Lesser Antarctica have led to the conclusion that there is no broad depression in the rock floor between the Ross Sea and the Weddell Sea. Antarctica is one continent, although the area

is not as great as the ice sheet would suggest. Several mountainous areas, such as that to the northwest of the broad ice-filled depression running from the Ross Ice Shelf towards the Amundsen and Bellingshausen Seas, would be islands were the ice to melt.

The major results from the seismic traverses in Lesser Antarctica during the three year period are given in tables and illustrated in profiles. — V.S.N.

- 185-566. Pratt, J. G. D. Seismic soundings across Antarctica: Trans-Antarctic Exped., 1955-1958, Sci. Repts., no. 3, 69 p., 1960.

The results of seismic soundings across Antarctica are presented in four parts. Part 1 discusses the seismic equipment and field techniques. In part 2 the methods used in the reflection survey of the ice cap from Southice through the South Pole to Plateau Depot are discussed, and depth results are given in a table. Part 3 discusses the refraction shooting program at Southice which had the primary aim of obtaining information about the velocity of seismic waves in ice, especially in the weathered layer. Results are given in tables and graphs. In part 4, the methods used to determine the thickness of the Filchner Ice Shelf from data of a reflection survey at Shackleton are discussed, and the results are given in tables and graphs. Lastly, three appendices present a glossary, the metric units employed, and a table of ray-tracing results to be used in computing weathering corrections as discussed in part 3. — V.S.N.

STRENGTH AND PLASTICITY

- 185-567. Reiner, Markus. Deformation, strain and flow—an elementary introduction to rheology: New York, Interscience Publishers, Inc., 347 p., 1960.

This textbook is a revision and enlargement of the first edition published in 1949. Chapters 1 through 6 discuss the mechanics of continua, that is, mechanics of material points, systems of material points, rigid bodies, and systems of rigid bodies. Chapters 8 to 13 show how essential rheological properties can be reduced to the 3 fundamental properties of elasticity, plasticity, and viscosity. Chapters 14 through 19 treat problems of physical nonlinearity, the phenomena of work hardening, and second-order phenomena. The text is concluded with a chapter on notations and with a bibliography. — V.S.N.

- 185-568. Pearson, Carl E. Theoretical elasticity: Cambridge, Harvard University Press, 218 p., 1959.

The fundamental concepts of stress, deformation, and linear elasticity are treated by using tensors. Vectors, index notation, differential geometry of space, and rotation of coordinates are concisely described in the first chapters. Green's identities and other integral equations in potential theory and the useful methods of variational calculus are reviewed. Additional topics covered concisely are elasticity equations in thermodynamics, vibrations and body and surface waves, and nonlinear elasticity. The mathematical treatment is clear, fairly complete, and rigorous. — E. C. R.

- 185-569. Caputo, Michele. Deformation of a layered earth by an axially symmetric surface mass distribution: Jour. Geophys. Research, v. 66, no. 5, p. 1479-1483, 1961.

Series expressions are developed for the surface displacements of a spherical earth model, deformed by both surface tractions and body forces arising from an axially symmetric distribution of mass over its surface. The model

consists of $m-1$ homogeneous elastic spherical shells, plus an inner core which is treated either as elastic or as a liquid.

This solution is more rapid than that which treats the problem as a special case (zero frequency) of the normal mode theory of a vibrating layered sphere; for the nonsymmetric case there is no advantage in this method over the normal mode theory. — D. B. V.

- 185-570. Usami, Tatsuo. Solutions of the equations of equilibrium of a homogeneous and isotropic elastic body referring to spheroidal coordinates: [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 2, p. 97-112, 1960.

The equation of equilibrium of a homogeneous and isotropic elastic body is solved in the prolate and oblate spheroidal coordinates for the cases of $m=0$, 1, and 2. Equations are derived for a three part solution: the first part satisfies $\Delta=0$ and $\bar{\omega}=0$; the second part satisfies $\Delta=0$ and $\bar{\omega}\neq 0$; and the third part satisfies $\Delta\neq 0$ and $\bar{\omega}\neq 0$. — V. S. N.

- 185-571. Donath, Fred A. Experimental study of shear failure in anisotropic rocks: *Geol. Soc. America Bull.*, v. 72, no. 6, p. 985-990, 1961.

Preliminary work has shown that planar anisotropy (foliation) may have a marked effect on both the breaking strength and the angle of shear fracture in rocks. For rocks experimentally deformed at room temperature and under low confining pressure, curves of breaking strength versus inclination of anisotropy are concave upward and parabolic in form. Shear fractures tend to develop parallel to well-developed planar anisotropy for inclinations up to 45° - 60° to the direction of maximum pressure. — Author's abstract

- 185-572. Bellière, J. Déformation plastique et déformation rupturale [Plastic deformation and ruptural deformation]: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 257-260, 1960.

In plastic deformation the continuity of the deformed objects is maintained; in ruptural deformation it is broken. The type that will prevail in a given instance depends on the following factors, aside from such dynamic elements as strength and direction of the forces involved: nature of the rock; depth in the crust (level of regional metamorphism); presence of anatexis or ultrametamorphic phenomena; scale of features observed; and, probably, time at which deformation occurred in the tectonic phase. Special attention is given to the conditions in which mylonitization appears. — D. B. V.

- 185-573. Brace, W. F. Analysis of large two dimensional strain in deformed rocks: *Internat. Geol. Cong.*, 21st, Copenhagen 1960, Proc., pt. 18, p. 261-269, 1960.

For a general nonhomogeneous strain of importance in structural geology the relatively simple equations of homogeneous strain can be applied over small regions. It is assumed that these regions are large enough within a geologic structure that the strain components can be measured. The immediate purpose of strain measurement and analysis is to find the magnitude and orientation of principal strains.

The most suitable strain components appear to be the quadratic elongation (λ) and unit shear (γ). These are easily measurable and can be used in a Mohr diagram to investigate variation of strain and to find principal strains semigraphically. The method is described and applied to a stretched pebble, a deformed brachiopod, and a group of three stretched belemnites. Principal

strains and change of area can thus be found more simply for combined measurements than by analytical methods.

The results applied here to plane strain hold also for any plane perpendicular to one of the three principal strain axes; determination of strain axes in two such planes completely determines strain in three dimensions. The method therefore can be extended to more general types of finite strain that are of interest in structural geology. — D. B. V.

- 185-574. Kieslinger, Alois. Residual stress and relaxation in rocks: Internat. Geol. Cong., 21st, Copenhagen 1960, Proc., pt. 18, p. 270-276, 1960.

All rocks of the crust are in a condition of strong elastic compression. When pressure is removed by erosion, relaxation and volume increase take place very slowly and incompletely. The resulting sheeting at the surface, most prominent in granite, occurs in all types of rock. In the outer zone of relaxation, stress is oriented in definite directions, but at greater depth it is hydrostatic. Artificial splitting and economical quarrying of granite are possible only in this outer zone of relaxation, which extends at most to 40-50 m below the surface.

Because of the incomplete elasticity of rocks, even small pieces such as testing cubes retain considerable residual stress; this accounts for striking anomalies in the testing of materials. The relaxation tendencies make use of petrofabrics if possible. Knowledge of relaxation is critically important in quarrying and for the understanding of rock slips and many other geologic phenomena. — D. B. V.

- 185-575. Iida, Kumizi; Wada, Tatsuhiko; Aida, Yoko; and Shichi, Ryuichi. Measurements of creep in igneous rocks; Nagoya Univ. Jour. Earth Sci., v. 8, no. 1, p. 1-16, 1960.

Creep measurements in granitic rocks, basalt, rhyolite, andesite, and serpentine are described. An ordinary bending apparatus was used, and measurements were limited to the range of small stresses at room temperature and atmospheric pressure. At low stresses pseudoviscous flow-type creep is observed in serpentine and in some rhyolite, and elastic flow-type creep is observed in granitic rocks, in some rhyolite, and in andesite.

For serpentine and basalt the creep rate decreases with increase in load; moreover, in the case of basalt negative creep is observed. The increase in creep resistance is a result of the formation of substructures at grain boundaries. The abnormal or reverse creep in basalt is probably a result of precipitation at grain boundaries. Overall results suggest that considerable rock deformation will occur eventually even under very small strain. — V. S. N.

- 185-576. Konstantinova, A. G. Vremennoye raspredeleniye energii uprugikh impulsov pri razrushenii gornykh porod [Time distribution of energy of elastic impulses during destruction of rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1580-1592, 1960.

On the basis of an analysis of the temporal distribution of the energy of elastic impulses, certain aspects of the fissure-forming process during the destruction of rock samples under uniaxial compression and in the coal layers during the time prior to sudden ejection of coal and gas are explained. — Author's abstract, A. J. S.

- 185-577. de Wit, G., and Koehler, J. S. Interaction of dislocations with an applied stress in anisotropic crystals: *Phys. Rev.*, v. 116, no. 5, p. 1113-1120, 1959.

The equilibrium shape of a dislocation segment between two pinning points in the same glide plane is calculated. The assumption is made that the dependence of the dislocation self-energy on the geometry of the dislocation line can be expressed by using an energy per unit length, E , which is a function only of the angle, θ , between the Burgers vector and the tangent of the dislocation. Only glide of the dislocation, not climb, is considered. The results obtained are compared with those for elastically isotropic crystals. It is found that the character of the dislocation shape is altered considerably if $E - d^2E/d\theta^2$ can be negative. It is suggested that the change in sign of this quantity is associated with diffusionless phase changes. — Authors' abstract

- 185-578. Koehler, J. S., and de Wit, G. Influence of elastic anisotropy on the dislocation contribution to the elastic constants: *Phys. Rev.*, v. 116, no. 5, p. 1121-1125, 1959.

Calculations of the dislocation contribution to the measured elastic constants of face-centered cubic crystals are made as follows. First, the displacement of a pinned dislocation segment under an externally applied stress is evaluated. Then the contribution to the resulting macroscopic distortion of the specimen resulting from the motion of all the dislocations present is calculated. The results are that the contributions for given dislocation arrangements increase with increasing anisotropy. For copper and lead the contributions can amount to a few percent in a pure well annealed crystal and can be as large as 10 percent in slightly deformed crystals. Edge dislocations are found to make about ten times larger contributions than a similar density of screw dislocations. — Authors' abstract

- 185-579. Gunter, B. D., and Parker, F. L. The physical properties of rock salt as influenced by gamma rays: Oak Ridge, U.S. National Laboratory, ORNL-3027, 71 p., 1961.

The response of dome and bedded rock salt aggregates to gamma radiation and temperature changes was studied. The compressive strength, yield strength, modulus of elasticity, and apparent elastic limit were investigated, and short-term creep tests were made. Data are presented in tabular and graphic form. Within the statistical variation of the experiment, radiation causes only minor changes in the physical properties of rock salt and, therefore, would not prohibit the disposal of radioactive wastes in salt cavities. — V. S. N.

- 185-580. Panek, Louis A. Measurement of rock pressure with a hydraulic cell: *Mining Eng.*, v. 13, no. 3, p. 282-285, 1961.

An apparatus and a technique developed by the U.S. Bureau of Mines to measure total existing rock pressure directly are described in detail. The apparatus has been used to measure pressure in diabase, limestone, gray-wacke, iron ore, and concrete (drift linings) in three mines over a period of three years. The results show that pressure measurements obtained from arrays in the same drift agree within the limits of experimental error and are consistent with pressures that may be predicted by theory for simple stress situations. The technique is intended primarily for use in monitoring rock pressure at locations that may be of particular interest to investigation of ground control principles, or that may be critical to production where failure

to control rock pressure could disrupt mining. The apparatus consists of 4 strain gages cemented in vertical slots in the rocks and a flat hydraulic pressure cell cemented in a horizontal slot. Procedures are described in detail. — V.S.N.

- 185-581. May, A. N. The measurement of rock pressures induced by mineral extraction: Canadian Mining and Metall. Bull., v. 53, no. 582, p. 747-753, 1960; also in Canadian Inst. Mining and Metall. Trans., v. 63, p. 497-503, 1960.

A stressmeter developed to measure unidirectional stress changes in absolute units is described. The instrument is designed to measure the stress condition in the interior of rocks surrounding underground openings. The stressmeter may be installed at the end of a diamond drill hole and left in position to record any subsequent changes in stress, or three instruments can be used in conjunction with a trepanning operation to allow the existing stress condition to be determined. Initial laboratory work and field trials are described. — V.S.N.

- 185-582. Hast, Nils. The measurement of rock pressure in mines: Sveriges Geol. Undersökning, Årsb. 52, no. 3, Ser. C, no. 560, 183 p., 1958.

A method of measuring the absolute value and direction of principal stresses of rock pressure in mines is described in the first part, and the results of application of the method in three mines in Sweden are presented in some detail in the next three parts. Hitherto unsuspected horizontal stresses of a magnitude far exceeding vertical load at the same points were revealed. A fifth part deals with stress conditions in block caving.

Part 6 is devoted to a survey of the horizontal rock pressure determined at six mines in Scandinavia. There appears to be a genetic connection between the horizontal rock pressure and secular movements in this area. Earthquakes may be due to local release of cumulative stresses built up over long periods by such movements. In certain areas where earthquakes have recurred along the same fault line, the accumulation of stress can be followed by periodic measurements of rock pressure; in this way it should be possible to ascertain when there is serious risk of an earthquake. — D. B. V.

- 185-583. Zumberge, James H., Giovinetto, Mario, Kehle, Ralph, and Reid, John. Deformation of the Ross Ice Shelf near the Bay of Whales, Antarctica: Am. Geog. Soc., IGY World Data Center A, Glaciol. Rept. Ser., no. 3, 148 p., 1960.

Parallel crevasses oriented normal to the axes of firm folds in the Ross Ice Shelf between Roosevelt Island and the Bay of Whales, Antarctica, were studied during the International Geophysical Year 1957-58 and 1958-59. Seismic data in the folded area reveal that the shelf ice has a thickness of 70-133 m and floats in water more than 500 m deep. The folds and crevasses are produced by horizontal compressional stresses induced by merging of ice streams from the east and west sides of Roosevelt Island. Plastic deformation from lateral compressive stresses has produced increased densification in the folded parts of the shelf ice.

Strain rates show that the axes of the firm folds are almost always perpendicular to the principal compressive axis and the crevasses essentially perpendicular to the principal tension axis. Comparison of strain rates in crevassed and noncrevassed areas defines a rupture criteria having the mathematical form of a surface of revolution around the line $s_1 = s_2$. — V. S. N.

- 185-584. Gaskell, T[homas] F. Under the deep oceans: New York, W. W. Norton and Company, 240 p., 1960.

This is a popular account of the scientific results achieved from the geophysical studies of the ocean floor conducted by the 1950 Challenger Expedition. The text includes the following chapters: geographical exploration - modern style, the earth and the oceans, seismic prospecting, the Moho, deep sounding, coral atolls, layer 2, sea-bed sediments, natural history, the Mediterranean, wandering continents, and deep drilling. The findings solved a number of old problems such as the origin of coral atolls and the status of the Mediterranean, and also brought forth new evidence for the theory of continental drift. — V. S. N.

- 185-585. Oulianoff, Nicolas. Transport des matériaux meubles sur les fonds océaniques [Transport of loose materials on the ocean bottom]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4410-4412, 1960.

Perpetual vibration of the earth's crust due to earthquakes and microseisms is considered the most important agent of transport of marine sediments, analogous to the "vibrating conveyors" used in industry. In comparison, the sporadic effect of turbidity currents is of secondary importance. — D. B. V.

- 185-586. Heezen, Bruce C. The rift in the ocean floor: Sci. American, v. 203, no. 4, p. 99-110, 1960.

The Mid-Atlantic Ridge, originally located by the 1873 Challenger Expedition, is now believed to be part of a continuous world-wide system of submarine ranges occupied by central rift valleys. Seismic mapping in the past few years has confirmed the existence in many parts of the world of this submarine ridge and rift system and the coincidence of the rift with a belt of mid-ocean earthquake epicenters. Landward expressions of this system are found in the East African Plateau rift valley system and in the Central Icelandic graben as well as in other parts of the world. The appearance of this system in some of the places where it has been mapped is described briefly, and the continental-drift, expanding-earth, and convection-current theories are discussed as possible explanations for the features. — V. S. N.

- 185-587. Matthews, D. H. Lavas from an abyssal hill on the floor of the North Atlantic Ocean: Nature, v. 190, no. 4771, p. 158-159, 1961.

Rocks dredged from an abyssal hill that rises 200 m from the Iberia Abyssal Plain, some 300 miles northwest of Lisbon, may represent material from "seismic layer 2." Most of the samples (354 out of 362) are highly altered vesicular basalt. These altered lavas were found to be slightly less magnetic than normal basalts, although their susceptibility (median value 5×10^{-4} emu per oersted per cm^3) and remanent magnetization (median value 5×10^{-3} emu per cm^3) lie within the known range of variation for basalts.

Compressional wave velocities were measured at room temperature and pressure parallel to a uniaxial compressive stress of a few tens of atmospheres; results are presented graphically. Variation of velocity with hydrostatic compacting pressure was measured under differential confining pressures of 1-1,000 kg per cm^2 ; the maximum increase in velocity with pressure was 30 percent. These results suggest that altered basalt flows could be common in layer 2 under the oceans. — D. B. V.

- 185-588. Fisher, Robert L. Middle America Trench: Topography and structure: Geol. Soc. America Bull., v. 72, no. 5, p. 703-720, 1961.

From 1952 to 1959 research vessels recorded 31,950 miles of echo-sounding traverses in and adjacent to the Middle America Trench, which extends from the Islas Tres Marías off western Mexico to the Cocos Ridge southwest of Costa Rica. The results are shown in a map of the submarine topography.

Seismic refraction studies of the trench structure, reported in a companion paper (see Geophys. Abs. 185-543), showed thick sediments in the Tres Marías Basin and at the shelf station off Guatemala. On a section off Guatemala normal to the trench, the depth to the M-discontinuity is about 9 km below sea level under the Pacific basin, 10 km under the outer ridge, 16 km under the trench, and 17 km under the shelf. The crust thickens from 5-7 to 10-17 km along this same section. The M-discontinuity is deeper and the crust thicker under the two southern stations than under the two central trench stations. The mantle is deeper under the Tres Marías Basin, where thick (1.5 km) sediments are found, than under the central stations.

The Gulf of Tehuantepec marks a major change in trench configuration and possibly in its age. — D. B. V.

- 185-589. Zverev, S.M. O stroenii osadochnoy tolshchi nekotorykh uchastkov Tikhogo okeana po dannym seismicheskikh otrazhennikh voln [On the structure of the sedimentary layer of some parts of the Pacific Ocean according to seismic reflection data]: Akad. Nauk SSSR Izv. Ser. Geol., no. 2, p. 80-86, 1961.

The results of deep reflection surveys in the northwest part of the Pacific Ocean in 1957-58 show that the bottom sediments in a deep-sea trench are homogeneous in comparison with the complexly layered shelf sediments, and that their thickness decreases gradually with distance from the trench. Complex relief of the basement on the slopes bordering the Kurile-Kamchatka trench is smoothed by the sedimentary fill; away from the trench the basement relief becomes more and more gentle. About 150-250 km from the axis of this trench large-amplitude fracture zones, probably the result of tectonic movement, cut all sedimentary layers and are expressed in the bottom relief.

The sediment thickness of the marginal slopes near the Aleutian trench is two or three times greater than that in the vicinity of the Kurile-Kamchatka trench, suggesting that their conditions of sedimentation are essentially different. — D. B. V.

- 185-590. Krylov, A. Ya., Lisitsyn, A. P., and Silin, Yu. I. Znachenie argon-kaliyevogo otnosheniya v okeanicheskikh ilakh [Significance of the argon-potassium ratio in ocean sediments]: Akad. Nauk SSSR Izv. Ser. Geol., no. 3, p. 87-100, 1961.

The K/Ar ratios, absolute ages, grain size, and mineralogic composition were determined for clastic materials in modern ocean sediments from various parts of the world: Antarctic ice-rafted material in the Indian and Pacific Oceans; diatomaceous and foraminiferal deposits in the Indian Ocean; red deep-sea oozes from the Indian and Pacific Oceans; and off-shore deposits in the Gulf of Bengal, near Somali, in the Tasman Sea, and in the Bering Sea. Results are tabulated.

As radiogenic argon was found to be completely or almost completely retained in even the finest particles of feldspar and mica, and as no appreciable adsorption of potassium from sea water could be detected, it is concluded that most ocean sediments can be used for argon determinations of the age of the original rock and thereby can help solve a series of problems of marine geology.

and paleogeography. Many kinds of sediments, especially the more sandy or gritty, are suitable for the purpose. Those containing organic impurities, glauconite, and products of recent volcanism are of little use, however.

The results for particular areas are discussed and compared. — D. B. V.

Wilson, Gilbert M. Project Mohole demonstrates deep water drilling techniques. See Geophys. Abs. 185-366.

VOLCANOLOGY

- 185-591. Ault, W[ayne] U., Eaton, J[erry] P., and Richter, D. H. Lava temperatures in the 1959 Kilauea eruption and cooling lake: Geol. Soc. America Bull., v. 72, no. 5, p. 791-794, 1961.

The 1959 summit eruption of Kilauea Volcano, Hawaii, filled the crater of Kilauea Iki with a lake of lava 365 feet deep. Temperatures of the erupting basalt ranged between 1,060°C and 1,190°C. Temperatures down a 12.7 foot - deep hole, drilled into the crust of the lake 5 months after cessation of eruptive activity, agree with calculated temperatures based on the heat equation. The cooling effect of rainfall is pronounced only in the upper 3½ feet of the crust. — Authors' abstract

- 185-592. Tilley, C. E., and Scoon, J. H. Differentiation of Hawaiian basalts: Trends of Mauna Loa and Kilauea historic magma: Am. Jour. Sci., v. 259, no. 1, p. 60-68, 1961.

New analyses strengthen the conclusion that the historic lavas of Mauna Loa and Kilauea are derived from different magmatic batches. The presence or absence of hypersthene in the lavas seems to be related to the lime and silica content. Historically, Mauna Loa lavas as a batch are higher in silica and lower in lime than the Kilauea batch; lavas of the same silicity are lower in alkalis in the Mauna Loa type. The Kilauean lavas that carry hypersthene are the more silicic types and are lower in lime. — V. S. N.

- 185-593. Macdonald, Gordon A. The activity of Hawaiian volcanoes during the years 1951-1956: Bull. Volcanol., v. 22, p. 3-70, 1959; reprinted as Hawaii Univ. Inst. Geophysics, Contr. no. 14, 1959.

This summary of volcanic activity in Hawaii during the years 1951-56 (during which only Kilauea was active) includes the history of Kilauea, earthquakes during 1951 and early 1952, the 1952 eruption, earthquakes and ground tilt in 1953 and early 1954, the 1954 eruption, earthquakes and ground tilt during the second half of 1954 and early 1955, the 1955 eruption, conditions at Kilauea and Mauna Loa from June 1955 to December 1956, and probable submarine eruptions in 1955 and 1956. — D. B. V.

- 185-594. Morais, J. Custódio de. O vulcão dos Capelinhos da Ilha do Faial [The volcano of Capelinhos of the island of Fayal]: Univ. Coimbra Mus. Mineralog. Geol. Mem. e Notícias, no. 47, p. 11-16, 1959.

The eruption of Capelinhos volcano at the west end of Fayal Island and its products are described briefly, and the volcanological setting of the Azores is discussed. (See also Geophys. Abs. 173-361, 175-409, -410, 180-402). — D. B. V.

- 185-595. Svyatlovskiy, A. Ye. K vulkanam Kamchatki [Volcanoes of Kamchatka]: Moscow, Gosudarstvennoye Izdatel'stvo Geograficheskoy Literatury, 100 p., 1960.

A popular description is given of the volcanoes of Kamchatka. The illustrations consist of several aerial views of cones and craters and a map showing the location of active volcanoes: — J. W. C.

- 185-596. Gushchenko, I. I. Deyatel'nost' vulkanov severnoy Kamchatki v 1957 g. [The activity of the volcanoes of northern Kamchatka in 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 29, p. 3-6, 1960.

The activity of Klyuchevskaya during 1957 consisted mainly of gas emission from the central and eastern parts of the crater. Sheveluch, Ploskiy Tolbachik, and Kizimen were fumarolic. Activity of Bezmyanny declined; weak explosions were noted on January 30, March 1, and July 31, but otherwise activity consisted mainly of gas emission. — D. B. V.

- 185-597. Markhinin, Ye. K. Izverzheniye vulkana Zavaritskogo na ostrove Simushir osen'yu 1957 g. [Eruption of Zavaritskiy Volcano on Simushir island in the fall of 1957]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 29, p. 7-14, 1960.

Zavaritskiy Volcano in the Kurile Islands began to erupt on November 12, 1957 after 14 years of quiescence. The eruption was preceded by tremors and dull rumbling noises. Activity was explosive; ash, lapilli, and increasingly larger fragments were showered over the surrounding area. The active vent, located on the northwest shore of the crater lake, was still erupting on December 12; activity then was mainly gas emission with occasional small explosions. Fumarolic and solfataric activity elsewhere in the caldera was vigorous. The lake level has dropped about a meter since the eruption. — D. B. V.

- 185-598. Gushchenko, I. I. Aktivnost' vulkanov severnoy Kamchatki (s 1 yanvarya po 15 oktyabrya 1958 g.) [Activity of the volcanoes of northern Kamchatka (from January 1 to October 15, 1958)]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkan. Sta., no. 30, p. 3-6, 1960.

In the period in question Tolbachik, Kizimen, and Sheveluch were moderately fumarolic. Vigorous gas emission from the eastern part of the crater and weak ash-producing explosions on May 18 and July 4 and 18 were noted at Klyuchevskaya. Fumarolic activity from the earlier agglomerate flows from Bezmyanny continued intensively. Earthquakes and tremors from an epicenter in the Bezmyanny area were recorded at the seismic station at Klyuchi. — D. B. V.

- Bernshteyn, V. A. On the magnetic field on Zavaritskiy volcano (Simushir Island, Kurile Islands). See Geophys. Abs. 185-481.

- Tokarev, P. I. The Kozyrevsk seismic station. See Geophys. Abs. 185-147.

- 185-599. Sekiya, H. An analysis of volcanic activity of Mt. Asama (3d paper) [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 3, p. 71-81, 1960.

Several statistical properties of the volcanic activity of Mt. Asama in Japan are discussed. The secular variation and the mean properties over a 20-30 yr period of groups of volcanic activities (duration of eruption, number of earthquakes, probability of eruption, frequency of quantity of smoke, explosion energy) are shown in figures and tables. The correlation between the monthly number of microearthquakes or the quantity of smoke of class 5 (or more) with both the probability of eruption and explosion energy are calculated and illustrated. The fluctuation of observed frequency of smoke of class 5 or more is found to be more useful for the long range forecast of an eruption than correlations of energy or probability with earthquakes. — V.S.N.

- 185-600. Hamilton, W. M., and Baumgart, I. L. White Island: New Zealand Dept. Sci. Indus. Research Bull. 127, 84 p., 1959.

White Island is an active volcano in the Bay of Plenty and lies about 32 miles northeast of Whakatane, North Island, New Zealand, at lat 37°31' S., long 177°11' E. The island is $1\frac{1}{2}$ by $1\frac{1}{4}$ miles in size; the highest peak, Mt. Gisborne is 1,053 feet in elevation; and the crater, elongated east-west, is $\frac{3}{4}$ mile long by $\frac{1}{4}$ mile wide. Historical records indicate that the nature of the activity, consisting of fumaroles, hot springs, and intermittent minor eruptions of ash, has not altered materially in the last 125 years. The bulletin includes the following chapters by various authors: general description, history, volcanology 1927-29, physical and chemical investigations 1939-55, soils, vegetation, and birds, with a note on the mammal Rattus exulans Peale. — V.S.N.

- Lotze, Franz. Actuo-geologic characteristics of the year 1958. See Geophys. Abs. 185-114.

- 185-601. Glangeaud, L[ouis]. Introduction aux études sur "Plutons et volcans". Les deux magmas des plutons et des volcans. Leurs rapports avec le métamorphisme [Introduction to the studies on "Plutons and volcanoes." The two magmas of plutons and of volcanoes. Their relations to metamorphism]: Rev. Géographie Phys. et Géologie Dynam., v. 3, no. 2, p. 77-85, 1960.

The fundamental problems of plutonism, which are the origin of granite and metamorphism, are discussed in terms of experimental, geologic, and geophysical evidence and thermodynamic principles. Different models of the present crust are illustrated, relating observed facts to geophysical measurements in different types of oceanic and continental areas. A bibliography of 80 entries is given. — D.B.V.

- 185-602. Vymorokov, B. M. Kak deystvuyut geyzery [How geysers work]: Priroda, no. 11, p. 97-99, 1960.

The geyser mechanism is reviewed on the basis of studies of boreholes drilled in volcanic regions of New Zealand and Kamchatka. The activity in these boreholes is cyclic like that of geysers. — A.J.S.

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by JAMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, and others

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*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



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By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others

INTRODUCTION

Extent of Coverage

Geophysical Abstracts includes abstracts of technical papers and books on the physics of the solid earth, the application of physical methods and techniques to geologic problems, and geophysical exploration. The table of contents, which is alphabetically arranged, shows the material covered.

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memorandums) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

List of Journals

Lists of journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033-A) and subsequent issues through 184 (January-March 1961, Bulletin 1146-A) have been compiled into a single list, which may be obtained by writing to the U. S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 184. The following is an additional supplement that lists references cited in Geophysical Abstracts 186 that have not been listed previously.

Akad. Nauk SSSR Lab. Hidrogeol. Problem, Trudy -- Akademiya Nauk SSSR Laboratoriya Hidrogeologicheskikh Problem Trudy [Academy of Sciences U. S. S. R., Laboratory of Hydrogeological Problems Transactions]. Moscow (Moscow).

Akita Univ. Mining Coll., Research Inst. Underground Res. Rept. -- Report of the Research Institute of Underground Resources, Mining College, Akita University. Akita, Japan.

Astron. Jour. -- Astronomical Journal. American Astronomical Society. New Haven, Connecticut.

Balneol. Soc. Japan Jour. -- Journal of the Balneological Society of Japan. The Chemical Institute of Tokyo University. Tokyo, Japan.

De Re Metallica -- De Re Metallica [Concerning Noble Metals]. Montana School of Mines. Butte, Montana.

Fiji Geol. Survey Dept. Ann. Rept. for 1960 -- Geological Survey Department Annual Report for the Year 1960. Legislative Council of Fiji. Suva, Fiji.

Geol. Soc. Glasgow Trans. -- Transactions of the Geological Society of Glasgow. Geological Society of Glasgow. Glasgow, Scotland.

Geol. Soc. India Jour. -- The Journal of the Geological Society of India. Bangalore, India.

Grønlands Geol. Undersøgelse Misc. Papers -- Grønlands Geologiske Undersøgelse Miscellaneous Papers. København, Denmark.

Illinois State Geol. Survey Circ. -- Illinois State Geological Survey Circular. State of Illinois Department Registration and Education, Division of the Illinois State Geological Survey. Urbana, Illinois.

Inst. Physique du Globe Paris Annales -- Annales de l'Institut de Physique du Globe de Strasbourg, Université de Strasbourg. Strasbourg, Germany.

- Internat. Assoc. Geomagnetism and Aeronomy Bull. -- Bulletin of the International Association of Geomagnetism and Aeronomy. International Union of Geodesy and Geophysics. Paris, France.
- Irish Naturalists' Jour. -- The Irish Naturalists' Journal. Irish Naturalists' Journal Committee. Belfast, Northern Ireland.
- ISA Jour. -- ISA Journal. Instrument Society of America. Pittsburgh, Pennsylvania.
- [Japan] Kakioka Magnetic Observatory Rept. -- Kakioka Magnetic Observatory Report. The Kakioka Magnetic Observatory. Kakioka, Japan.
- Jour. Mines, Metals, and Fuels -- Journal of Mines, Metals, and Fuels. Books and Journals Private Ltd. Calcutta, India.
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- Minno-Geol. Inst. Godishnik -- Minno-Geolozhkiya Institut Godishnik [Yearbook of the Mining-Geological Institute]. Sofia, Bulgaria.
- Nauka i Zhizn -- Nauka i Zhizn. Vsesoyuznoye Obshchestvo po Rasprostraneniyu Politicheskikh i Nauchnykh Znanii [Science and Life. All Union Society for the Dissemination of Political and Scientific Knowledge]. Moskva (Moscow).
- Norsk Geog. Tidsskr. -- Norsk Geografisk Tidsskrift. Norske Geografisk Selska. [Norwegian Geographical Journal. Norwegian Geographical Society]. Oslo, Norway.
- Observatoire d'Utrecht Recherches Astron. -- Recherches Astronomiques de l'Observatoire d'Utrecht [Astronomical Research of the Observatory of Utrecht]. Utrecht, Netherlands.
- Papers in Meteorology and Geophysics -- Papers in Meteorology and Geophysics. Meteorological Institute. Tokyo, Japan.
- Pochvovedeniye -- Pochvovedeniye. Akad. Nauk SSSR V. V. Doluchayev Institut Pochvovedeni [Soil Science, Academy of Sciences, U. S. S. R., V. V. Doluchayev Institute of Soil Science]. Moskva (Moscow).
- Portugal Servicos Geol. Mem. -- Memoire Servicos Geologicos de Portugal [Memoirs of the Geological Survey of Portugal]. Lisbon, Portugal.
- Shui-Wen Ti-chih Kung-ch'eng Ti-chih -- Shui-Wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology]. Peiping, China.
- Sky and Telescope -- Sky and Telescope. Harvard College Observatory, Sky Publishing Corporation. Cambridge, Massachusetts.
- Soc. Chim. France Bull. -- Bulletin de la Société Chimique de France. [Bulletin of the Chemical Society of France]. Paris, France.
- Soc. Française de Minéralogie et de Cristallographie Bull. -- Société Française de Minéralogie et de Cristallographie Bulletin. Centre National de la Recherche Scientifique [Bulletin of the French Society of Mineralogy and Crystallography. National Center of Scientific Research]. Paris, France.
- Soc. Vaudoise des Sci. Nat. Bull. -- Bulletin de la Société Vaudoise des Sciences Naturelles. Société Vaudoise des Sciences Naturelles [Bulletin of the Vaudoise Society of Natural Sciences. Vaudoise Society of Natural Sciences]. Lausanne, Switzerland.
- Tasmania Dept. Mines Tech. Repts. -- Tasmania Department of Mines Technical Reports. Hobart, Tasmania.
- Univ. Sheffield Geol. Soc. Jour. -- Journal of the Geological Society of the University of Sheffield. Sheffield, England.
- Yellowstone Nature Notes -- Yellowstone Nature Notes. Yellowstone Library and Museum Association, Yellowstone National Park. Yellowstone Park, Wyoming.

Form of Citation

The abbreviations of journal titles used are those used in the U. S. Geological Survey publications and in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board of Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991-A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

Abstracters

Abstracts in this issue have been prepared by V. G. Gabriel, and A. J. Shneiderov, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstracter following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 186-1. Evernden, J[ack] F[oord], Curtis, G[arniss] H., Obradovich, J., and Kistler, R. [W.]. On the evaluation of glauconite and illite for dating sedimentary rocks by the potassium-argon method: *Geochim. et Cosmochim. Acta*, v. 23, no. 1/2, p. 78-99, 1961.

A stratigraphically well controlled sequence of glauconite and illite K-Ar dates was compared with a time scale controlled by biotite dates. The results show that when samples are selected carefully with regard to geologic history and prepared properly, glauconite and illite dates are almost as accurate as those determined on igneous biotite.

A tentative Tertiary time scale is presented, with lower boundaries as follows (in 10^6 yr): Pliocene-Miocene 12, Miocene-Oligocene 25, Oligocene-Eocene 33, Eocene-Paleocene 55, Paleocene-Cretaceous (Montian-Danian) 62, and Paleocene-Cretaceous (Danian-Maastrichtian) 67. — D. B. V.

- 186-2. Polevaya, N. I. Shkala absolyutnoy geokhronologii [The absolute geochronological scale]: *Akad. Nauk SSSR Doklady*, v. 134, no. 5, p. 1173-1176, 1960.

An absolute geochronological scale that incorporates the results of recent argon dating of glauconite in sedimentary rocks in the U. S. S. R. is presented and compared graphically with Holmes' new scale. Agreement with Holmes' scale is good, especially for the Cenozoic and most of the Mesozoic; disagreement involves mainly the subdivisions of the Paleozoic. The oldest of these rocks that can be dated paleontologically are 550×10^6 yr old according to the glauconite age. The lower boundary of the Cambrian is set, also on the basis of glauconite, at 600×10^6 yr. — D. B. V.

- 186-3. Shestakov, G. I., and Ivanov, I. V. K voprosu o graficheskom sposobe issledovaniya raskhozheniya vozrastov po svintsovo-uranovym otnosheniyam [On the problem of the graphic method of investigating the discordance in ages according to the lead-uranium ratios (with English summary)]: *Geokhimiya*, no. 3, p. 239-242, 1961.

A simple proof is offered of the correctness of the Ahrens-Wetherill graphic method of investigating discordant Pb-U ages (see *Geophys. Abs.* 162-164,

163-131, 166-11, 167-28). This proof permits a simple visual solution of some geochemical problems relevant to the metamorphism of uranium-bearing minerals. — D. B. V.

- 186-4. Danilevich, S. I. O dostovernosti "svintsovykh" vozrastov monazitov [On the reliability of the "lead" ages of monazites (with English abstract)]: *Geokhimiya*, no. 8, p. 736-747, 1960.

Analysis of the lead isotope ages of 59 ancient monazites from the Ukrainian S. S. R. shows that their reliability depends on the values of the coefficient A , defined as $A = (\text{Pb}^{207} \times 100) / (\text{Pb}^{\text{H}} \times \text{Th} / \text{U})$ (with nonradiogenic lead content Pb^{H} in percent by weight and the Pb^{207} content in atomic percent). Where $A \gg 1$, ages are usually concordant and where $A < 1$ they are not. It is shown that the analytical error is much smaller in cases where $A > 1$ than where $A < 1$. (See also *Geophys. Abs.* 183-9.) — D. B. V.

Vinogradov, A. P., Zykov, S. I., and Tarasov, L. S. Isotopic composition of admixtures of lead in ores and minerals as an indication of their origin and of time of formation. See *Geophys. Abs.* 186-462.

- 186-5. Stern, T[homas] W., and Rose, H. J., Jr. New results from lead-alpha age measurements: *Am. Mineralogist*, v. 46, no. 5/6, p. 606-612, 1961.

Improvement in the spectrochemical method for determining lead in zircon increases the usefulness of the lead-alpha (Larsen) age method. Good agreement is found between the lead-alpha ages and those obtained by isotope dilution analyses on twelve samples. These samples have calculated ages ranging from 400 to 1,200 million years. New lead analyses and revised lead-alpha ages are presented for 19 samples previously analyzed. — Authors' abstract

- 186-6. Fairbairn, H[arold] W., Hurley, P[atrick] M., and Pinson, W[illiam] H., [Jr.]. The relation of discordant Rb-Sr mineral and whole-rock ages in an igneous rock to time of subsequent $\text{Sr}^{87}/\text{Sr}^{86}$ metamorphism: *Geochim. et Cosmochim. Acta*, v. 23, no. 1/2, p. 135-144, 1961.

Interpretation of discordant Rb-Sr ages of coexisting biotite and K-feldspar in igneous rocks, mostly from Sudbury, Ontario, has been attempted using supplementary whole-rock ages. Following a model proposed by Compston and Jeffery (see *Geophys. Abs.* 180-250), it is postulated that, if the igneous body is a closed system, and a post-crystallization thermal event interrupts the accumulation of Sr^{87} in biotite and K-feldspar, the whole-rock analysis will give the true age and, owing to diffusion of radiogenic Sr out of biotite and K-feldspar, the apparent ages of these two minerals would be less than the whole-rock age. The common intersection of the three radiogenic growth lines ($\text{Sr}^{87}/\text{Sr}^{86}$ plotted against age) gives the time of metamorphism. For the majority of the 12 examples the model offers an apparently valid explanation of the discrepant ages in terms of known field relations and two orogenic events at 1.2×10^9 and 1.6×10^9 yr. — Authors' abstract

- 186-7. Ovchinnikova, G. V. Opredeleniye konstanty β -raspada rubidiya-87 geokhimicheskim metodom [Determination of the β -decay constant of Rb^{87} by the geochemical method (with English abstract)]: *Geokhimiya*, no. 5, p. 392-398, 1960.

The Rb^{87} and Sr^{87} contents of two micas of known ages were determined by the isotopic dilution method in order to calculate the β -decay constant of Rb^{87} .

A value of $\lambda = 1.38 \pm 10^{-11} \text{yr}^{-1}$ was obtained; this agrees well with the value of $1.39 \pm 0.05 \times 10^{-11} \text{yr}^{-1}$ previously determined by Aldrich and others (see *Geophys. Abs.* 167-231). Curves are given that show the relative errors in determination of Rb^{87} and Sr^{87} as a function of the isotopic composition of the mixture. — D. B. V.

- 186-8. Hart, Stanley R. The use of hornblendes and pyroxenes for K-Ar dating: *Jour. Geophys. Research*, v. 66, no. 9, p. 2995-3001, 1961.

The K-Ar ages of 12 hornblendes, 1 actinolite, and 2 pyroxenes were determined. When these ages are compared with ages of associated biotite, feldspar, or zircon, good agreement is found in most cases. No evidence is found for the existence of "excess" radiogenic argon in these hornblendes. A maximum limit of 5×10^{-7} cc STP/g can be placed on possible "excess" radiogenic argon in one sample. The potassium content of the amphiboles and pyroxenes is high enough so that Paleozoic or older samples can be easily dated, using present techniques. The rubidium content of the hornblendes is too low to be generally utilized for Rb-Sr dating. — Author's abstract

- 186-9. McDougall, Ian. Determination of the age of a basic igneous intrusion by the potassium-argon method: *Nature*, v. 190, no. 4782, p. 1184-1186, 1961.

The relative argon retention properties of minerals from a Tasmanian dolerite have been investigated in order to determine whether argon age measurements would be possible on rocks of low K content. The presence of chilled margins also suggested the possibility of dating whole rock samples. Results obtained on duplicate analyses of 2 sanidines, 2 plagioclases, and 1 pyroxene and on a single analysis of chilled dolerite are tabulated. The agreement between the duplicate analyses is better than 2 percent except in the case of the pyroxene. The range of calculated ages is $159\text{--}168 \times 10^6 \text{yr}$ for the plagioclase and pyroxene, suggesting that argon retention is high in both minerals. Sanidine ages are lower (down to $143 \times 10^6 \text{yr}$), suggesting argon leakage. The chilled dolerite gave an age of $148 \times 10^6 \text{yr}$, which is surprisingly good considering that the rock is composed mainly of devitrified glass, from which argon loss should be high.

It is concluded that the dolerites were intruded some $167 \times 10^6 \text{yr}$ ago (Early-Middle Jurassic boundary), and that minerals with low K content, such as occur in mafic igneous rocks, can be used for K-Ar dating purposes. — D. B. V.

- 186-10. Plevaya, N. I., Kazakov, G. A., and Murina, G. A. Glaukonity, kak indikator geologicheskogo vremeni [Glauconites as an indicator of geologic time (with English abstract)]: *Geokhimiya*, no. 1, p. 3-10, 1960.

The ages of 40 glauconites of known stratigraphic age, dated by the K-Ar method (using the decay constants $\lambda_K = 0.557 \times 10^{-10} \text{yr}^{-1}$ and $\lambda_\beta = 4.72 \times 10^{-10} \text{yr}^{-1}$), agree well with the existing time scale for the Meso-Cenozoic but not so well for the Paleozoic. The results confirm the possibility of argon dating of unfossiliferous strata on the Russian platform, and of comparing sedimentation rates in platform and geosynclinal areas. The oldest sediments of the central part of the Russian platform are dated by glauconites as $732\text{--}753 \times 10^6 \text{yr}$, and those of the southern Urals as $932 \times 10^6 \text{yr}$.

The effect of acids and heavy liquids used in treatment of the samples is discussed. It is concluded that glauconite is suitable for dating purposes, but that the mobility of K and Ar in different types of glauconite should be investigated systematically. (See also *Geophys. Abs.* 184-9.) — D. B. V.

- 186-11. Tamers, M[urphy] A., Stipp, J. J., and Collier, J. High sensitivity detection of naturally occurring radiocarbon—pt. 1: Chemistry of the counting sample: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 266-276, 1961.

The most promising method of increasing the sensitivity of C^{14} dating is the use of radiation detection techniques capable of counting large quantities of carbon; one of these is the use of the liquid scintillation spectrometer. This paper presents a means by which the entire counting solution can be synthesized from the sample to be dated, using benzene as the solvent. The chemistry and the procedure are described in detail. The chemical steps involve no special equipment or training; a 20-ml sample can be produced by 2 man-days of work, and the entire procedure can be completed in less than a week. — D. B. V.

- 186-12. Nygaard, K. J. A liquid scintillation counter for radiocarbon: *Appl. Sci. Research*, sec. B, v. 9, no. 2, p. 89-92, 1961.

Measurements have been made of the radiocarbon counting performance of a liquid scintillation coincidence counter used in conjunction with an anticoincidence shield counter at the Trondheim (Norway) dating laboratory. At room temperature the system has a counting efficiency of 59 percent at a background of 16 counts per minute. — D. B. V.

- 186-13. Straka, Herbert. Relative und absolute Datierungen quartärer Ablagerungen [Relative and absolute datings of Quaternary deposits]: *Naturwissenschaften*, v. 48, no. 9, p. 324-332, 1961.

Quaternary chronology as determined by various methods is reviewed. Pollen analysis and tephrochronology are relative methods; their results must be confirmed by absolute dating either by varve chronology (limited mainly to Scandinavia) or by radiocarbon dating. Quaternary chronology is a striking example of interdisciplinary cooperation between botany, geography, geology, mineralogy, physics, and even prehistory and zoology. A 72-item bibliography is given. — D. B. V.

- 186-14. Pellas, Paul. Métamictisation des allanites. Possibilité de déterminer des âges géologiques [Metamictization of allanites. Possibility of determining geologic ages]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3280-3282, 1961.

Study of the crystalline state and radioactivity of 53 allanites from pegmatites from different parts of the world shows that the spacing of the (211), (113), and (300) planes increases upon exposure to radiation, and that this increase is a function of time. With the aid of a curve constructed for allanites of known age, the ages of other allanites were calculated and found to fit well with other evidence.

It is concluded that if the method is applied carefully, the geologic age of allanites can be determined from their lattice expansion. The age thus obtained is the true age only if the mineral has not been subjected to heating subsequent to the original crystallization; metamict allanites are more sensitive to thermal effects than are zircons. The method should be a useful semiquantitative measure of the age of allanites in thin sections of granites and other igneous rocks. A precision of ± 10 percent is attainable under favorable conditions. — D. B. V.

- 186-15. Pasteels, Paul. L'âge des halos pleochroïques du granite d'Habkern et de quelques roches du massif de l'Aar [Age of pleochroic haloes

of the Habkern granite and of some rocks of the Aar massif]: Schweizer. Mineralog. Petrog. Mitt., v. 40, no. 2, p. 261-266, 1960.

The effect of metamorphism on pleochroic haloes in biotite in rocks of the Aar massif and in the Habkern granite is investigated. The halos in the north part of the Aar massif were weakened during the Alpine orogeny; this demonstrates that a weak epimetamorphism can have an effect on the halos. The halos in the Habkern granite are 300 million years old and appear to have been effected very little by the Alpine orogeny; this conclusion agrees well with the fact that no metamorphic effects are apparent in thin sections. — J. W. C.

- 186-16. Goldich, Samuel S., Nier, Alfred O., Baadsgaard, Halfdan, Hoffman, John H., and Krueger, Harold W. The Precambrian geology and geochronology of Minnesota: Minnesota Geol. Survey Bull. no. 41, 193 p., 1961.

Radioactivity dating of a large number of igneous and metamorphic rocks by the K-Ar and Rb-Sr methods is the basis for revision of the classification of the Precambrian rocks of Minnesota. The major divisions of the three-fold classification are made at time boundaries of 2.5 and 1.7 billion years corresponding to the time of two major orogenies, the Algoman and the Penokean, respectively; the eras are referred to as Early, Middle, and Late Precambrian. The analytical methods used are explained in detail and include a comparison of the results by the two methods and a discussion of some of the problems in evaluating radioactivity ages. The principal Precambrian rock units described in earlier geologic investigations are reviewed, new field and laboratory observations presented, and the geologic history interpreted with the aid of the K-Ar and Rb-Sr ages. The geologic results are presented on a geographic basis dictated by the distribution of outcrops in Minnesota. The general problems of correlation and development of a quantitative time scale are considered, and the geologic succession and chronology of the Minnesota Precambrian are shown in a table. Locations and brief descriptions of the dated samples are included in the appendix. — V. S. N.

- 186-17. Miller, Robert D., and Scott, Glenn R. Late Wisconsin age of terrace alluvium along the North Loup River, central Nebraska: a revision: Geol. Soc. America Bull., v. 72, no. 8, p. 1283-1284, 1961.

A radiocarbon age of $10,500 \pm 250$ yr on shell material near the base of a terrace along the North Loup River in Howard County, Nebr., dates the alluvial sequence as late Wisconsin rather than Kansan and Yarmouth as previously reported. — D. B. V.

- 186-18. Williams, John R., and Ferrians, Oscar J., Jr. Late Wisconsin and recent history of the Matanuska Glacier, Alaska: Arctic, v. 14, no. 2, p. 83-90, 1961.

The Matanuska Glacier is one of the largest of the glaciers that extend north from the snow and ice fields of the central Chugach Mountains of southern Alaska; it terminates in the upper Matanuska Valley. A C^{14} date of $8,000 \pm 300$ yr for peat from an undisturbed surface deposit 2.5 to 5 miles downstream from the terminus and overlying the innermost channel associated with glacial advances implies that more than 8,000 years ago the glacier terminated no more than 2.5 miles down-valley from its present position. An organic silt horizon of a soil, overlying outwash gravel associated with a pre-8,000

before present advance, is $3,620 \pm 250$ yr old and is correlated with the **Alti-thermal**; it represents a period of glacial retreat to a position southeast of the present terminus. In the last 4,000 years the glacier readvanced as much as one mile beyond its present position. — V. S. N.

- 186-19. Tupper, W. M., and Hart, S[tanley] R. Minimum age of the Middle Silurian in New Brunswick based on K-Ar method: Geol. Soc. America Bull., v. 72, no. 8, p. 1285-1288, 1961.

Five stratigraphically dated granitic bodies in New Brunswick have a K-Ar age between 380 and 400 million years. Four of the granites are post-Middle Silurian and pre-Pennsylvanian in age. The fifth granite body is post-Middle Silurian and pre-Late Devonian. This indicates a minimum age of 380 million years for Middle Silurian time in New Brunswick. — Author's abstract

- 186-20. Herz, Norman, Hurley, P[atrick] M., Pinson, W[illiam] H., [Jr.], and Fairbairn, H[arold] W. Age measurements from a part of the Brazilian shield: Geol. Soc. America Bull., v. 72, no. 7, p. 1111-1120, 1961.

The K-Ar age determinations on micas from Precambrian granitic rocks of the Quadrilátero Ferrífero, Minas Gerais, Brazil, suggest three ages of intrusion: $2,400 \times 10^6$ yr (gneiss within the Bação complex), $1,350 \times 10^6$ yr (rocks in the northern part of the Bação complex and also in a region 7 km north of the nearest known Minas series metasediments of late Precambrian age); and $450-550 \times 10^6$ yr (gneiss in the eastern part of the area, granitized beds in the Minas series, and granite between Minas beds and the $1,350 \times 10^6$ yr old granite). Other ages, ranging between 595 and $1,080 \times 10^6$ yr, may represent the effects of a younger metamorphism. — D. B. V.

- 186-21. Heusser, Calvin J. American Geographical Society southern Chile expedition 1959; Final report: New York, American Geographical Society, 22 p., 1961.

As a sequel to the long-term research program of the American Geographical Society on late-Pleistocene (late glacial and post glacial) climates, work was undertaken in the Laguna de San Rafael, western Patagonia, Chile, to establish chronological data that might be correlated with climatic fluctuations in other parts of South America and the Southern Hemisphere and with those of northwestern North America. The ancient moraines forming the laguna rim, the palynology and stratigraphy of related radiocarbon-dated peat sections, and the ages of modern morines provide the basis for interpreting the environments that have prevailed since the last glaciation. The late Pleistocene chronology from the Pacific Northwest based on C^{14} dates and on peat and pollen stratigraphy is reviewed. Evidence from northwestern North America and from Patagonia and related regions including Australia shows a general accord, compatible with the belief that climatic events of the late and post glacial are in phase; the harmonious glacier variations since the middle of the nineteenth century are particularly noted. The need for supplementary data for increased understanding of polar hemispheric relations is emphasized. — V. S. N.

- 186-22. de Waard, H., and Straka, H[erbert]. C^{14} -Datierung zweier Torfproben aus Madagascar [C^{14} -dating of two peat samples from Madagascar]: Naturwissenschaften, v. 48, no. 2, p. 45, 1961.

Two Madagascan peat samples from a depth of 780-800 cm in borehole B 25 south of Sanganoro Sud and from a depth of 900-930 cm in borehole B 127 east

of Soavinandriana have been dated by radiocarbon at $4,200 \pm 80$ yr and $8,165 \pm 90$ yr, respectively. From this, the rate of peat accumulation in this tropical area is calculated as 10.5-15 cm per century, compared to 5.1-9.4 cm per century for similar peats (swamp and forest) from central Europe. — D. B. V.

- 186-23. Leakey, L. S. B., Evernden, J[ack] F[oord], and Curtis, G[arniss] H. Age of Bed I, Olduvai Gorge, Tanganyika: *Nature*, v. 191, no. 4787, p. 478-479, 1961.

Olduvai Gorge in Tanganyika is famous for its unique Pleistocene section carrying a rich fossil fauna and long sequences of stages of evolution of early Stone Age cultures. In order to clarify the age relations of Bed I and Bed II (both have been considered by some to be lower middle Pleistocene, whereas others claim that Bed II is lower Pleistocene), K-Ar ages were determined on samples of biotite and oligoclase from tuffs in the top and on 7 anorthoclases from tuffs in the bottom of Bed I. The decay constants $\lambda_\beta = 4.72 \times 10^{-10} \text{ yr}^{-1}$ and $\lambda_k = 0.584 \times 10^{-10} \text{ yr}^{-1}$ were used. The anorthoclases range between 1.6 and 1.9×10^6 yr, averaging 1.75×10^6 yr. The samples from the top of the bed average 1.23×10^6 yr. It is concluded that the Olduvai culture and Villafranchian fauna are synchronous and about 1.75×10^6 yr old.

An age of 360,000 yr has been obtained on a post-Chellean II tuff in Bed II. — D. B. V.

- 186-24. Bonhomme, Michel. Âges absolus dans le massif granitique de Bouna en Haute-Volta et dans le granite de Windéné en Côte-d'Ivoire [Absolute ages in the Bouna granitic massif in Upper Volta and in the Windéné granite in the Ivory Coast]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 25, p. 4016-4017, 1961.

The ages of biotites from the Kosso migmatite and granite, the Bouna massif in Upper Volta, and the Windéné granite in the Ivory Coast were determined by the Rb-Sr method as $2,057 \pm 69 \times 10^6$ yr, $2,032 \pm 46 \times 10^6$ yr, and $2,050 \pm 35 \times 10^6$ yr, respectively. All three, therefore, belong to the same orogenic cycle. If, as has been suggested, the Kosso migmatite is actually older than the Kosso granite, the age obtained is that of recrystallization in the course of granitization. — D. B. V.

- 186-25. Bonhomme, Michel, Mendès, Francisco, and Viallette, Yves. Âges absolus par la méthode du strontium des granites de Sintra et de Castro Daire au Portugal [Absolute ages of the Sintra and Castro Daire granites in Portugal by the strontium method]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3305-3306, 1961.

Biotites from two Portuguese granites have been dated by the Rb-Sr method as follows: Sintra granite, in the vicinity of Lisbon (intruded into Jurassic and overlain by Oligocene) — $85 \pm 8 \times 10^6$ yr, or Late Cretaceous; Castro Daire granite, in Beira-Alta province (intruded into Stephanian but pre-Autunian) — $282 \pm 7 \times 10^6$ yr or late Stephanian. — D. B. V.

- 186-26. Longinelli, A. Age of the pleochroic-halos of the quartz-monzonite of eastern Elba: *Experientia*, v. 16, no. 10, p. 439, 1960.

Study of the pleochroic haloes in biotite in the quartz monzonite stock near Porto Azzurro in eastern Elba suggests that the stock belongs to the same magmatic phase as the Monte Capanne pluton (see also *Geophys. Abs.* 169-22). — D. B. V.

- 186-27. Chessex, Ronald, and Vuagnat, Marc. L'âge du massif de Traversella (Piémont, Italie) par la méthode des "dommages dus à la radioactivité" [The age of the Traversella massif (Piedmont, Italy) by the method of damage due to radioactivity]: Soc. Vaudoise des Sci. Nat. Bull., v. 67, pt. 7, no. 303, p. 395-406, 1961.

Age determinations on zircons from the Traversella diorite massif in Turin Province, Italy, are reported. The composition of the massif varies from diorite to quartz monzonite; samples to be dated were chosen from both phases. The age of the quartz monzonite was found to be $26 \pm 3 \times 10^6$ yr and for two quartz diorite samples to be $29 \pm 4 \times 10^6$ and $31 \pm 4 \times 10^6$ yr. The 31 million year date is thought to be the minimum age of the time of crystallization of the Traversella massif; this is further confirmed by two $31 \pm 1 \times 10^6$ yr K-Ar dates determined at the University of California on biotite from the quartz monazite and diorite phases. Geologic data suggest that the massif was probably intruded immediately following the Alpine movements of middle Oligocene; although in other areas these movements continued after the Oligocene, the character of the Traversella massif indicates that important tectonic movements in this region had ceased at the time of its intrusion. — V. S. N.

- 186-28. Krummenacher, D[aniel], Evernden, J[ack] F[oord], and Vuagnat, M[arc]. Sur l'âge absolu de la peridotite micacée de Finero (zone d'Ivrée) [On the absolute age of the Finero mica-peridotite (Ivrea zone)]: Archives Sci. (Genève), v. 13, no. 3, p. 369-373, 1960.

The apparent age of phlogopite from a peridotite near Finero in the Ivrea zone of the Alps has been determined by the K-Ar method as $246 \pm 4 \times 10^6$ yr, or Middle Permian according to the new geochronological scales. The mafic and ultramafic complex to which this rock belongs is therefore definitely pre-Alpine and unrelated to the Alpine ophiolites. The age is somewhat lower than that of the Baveno granite (see also Geophys. Abs. 180-13, 182-43), but field observations suggest that the mafic rocks of the Ivrea zone are older than the granite; the discrepancy could be due to differential argon loss during a phase of reheating, probably the result of intrusion of the Tertiary granodiorites. — D. B. V.

- 186-29. Grünenfelder, M., and Hafner, S. Das Zirkon-Alter granitischer Gesteine aus dem Gotthardmassiv [The zircon age of granitic rocks from the Gotthard massif (with English summary)]: Experientia, v. 15, no. 7, p. 295, 1961.

The U^{238}/Pb^{206} , U^{235}/Pb^{207} , and Pb^{207}/Pb^{206} ages of zircons from the Fibbia gneiss and the Rotondo granite in the Gotthard massif in the Alps have been measured using isotope dilution techniques. The results on the Fibbia gneiss give evidence of Hercynian orogenic events some 300×10^6 yr ago, confirming conclusions based on field and petrologic studies. The Rotondo granite, formerly considered to be Hercynian, is only $140-170 \times 10^6$ yr old, or Alpine (post-Triassic phase); this agrees with the results of petrofabric studies that showed the Rotondo pluton to be devoid of the foliation and lineation imparted to other rocks of the massif during the Alpine orogeny. — D. B. V.

- 186-30. Bonhomme, Michel; Philibert, Josette; Roques, Maurice; and Vialette, Yves. Âges absolus dans le Viséen et dans le Stéphanois du Massif Central français [Absolute ages in the Viséan and Stephanian of the French Massif Central]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 20, p. 3084-3086, 1961.

Four samples from 3 tuffs interbedded in the Carboniferous of the Massif Central of France have been dated by the Rb-Sr method, using a decay constant of $\lambda = 1.47 \times 10^{-11} \text{ yr}^{-1}$. The results are as follows: Malavaus tuff (biotite), $328 \pm 5 \times 10^6$ yr; Châteauneuf tuff (biotite), $324 \pm 4 \times 10^6$ yr; Châteauneuf tuff (chlorite), $334 \pm 36 \times 10^6$ yr; mean of latter two (both from the uppermost Viséan), $328 \pm 3 \times 10^6$ yr; biotite from the Brassac tuff (base of Upper Stephanian), $288 \pm 8 \times 10^6$ yr. — D. B. V.

- 186-31. Vialette, Yves. *Âge absolu du granite viséen de Gien-sur-Cure (Nièvre) dans le Massif Central français* [Absolute age of the Viséan granite of Gien-sur-Cure (Nièvre) in the French Massif Central]: Acad. Sci. [Paris] *Comptes Rendus*, v. 252, no. 25, p. 4018-4019, 1961.

Biotite from the Gien-sur-Cure granite in the Morvan has been dated by the Rb-Sr method as $334 \pm 7 \times 10^6$ yr; this fixes the limit between the lower and upper Viséan and fits well with earlier determinations of the base of the upper Stephanian and top of the Viséan (see Geophys. Abs. 186-30). — D. B. V.

- 186-32. Butcher, N. E. Age of the orogeny and granites in southwest England: *Nature*, v. 190, no. 4772, p. 253, 1961.

As the Dartmoor and related granites form one of the key points of the revised geological time scales of Holmes (see Geophys. Abs. 180-1) and Kulp (see Geophys. Abs. 183-2), their stratigraphic relations need to be determined as precisely as the field evidence will allow. The granites intrude a folded and faulted sequence in which the youngest paleontologically datable sediments are lower Westphalian; it is reasonable to suppose, however, that younger Westphalian or perhaps even Stephanian sediments, now removed by erosion, could have been present in the invaded section. Therefore, on the present evidence, it is preferable to regard the main orogenic movements in Devon and Cornwall as being of essentially the same age as those in the nearby Somerset coalfield, where they affect lower Stephanian strata. If the intrusions are indeed Permian rather than Late Carboniferous, the length of time allotted to the Carboniferous in the time scales would be affected. — D. B. V.

- 186-33. Dodson, M. H., Miller, J[ohn] A., and York, D. Potassium-argon ages of the Dartmoor and Shap granites using the total volume and isotopic dilution techniques of argon measurement: *Nature*, v. 190, no. 4778, p. 800-802, 1961.

The results of new K-Ar measurements on biotites from the Shap and Dartmoor granites of England are reported. Both the total volume and the isotopic dilution techniques were used, the former at Cambridge and the latter at Oxford. The mean values, weighing all determinations equally, are $265 \pm 5 \times 10^6$ yr for the Dartmoor granite and $397 \pm 8 \times 10^6$ for the Shap. These figures are in good agreement with the K-Ar and Rb-Sr ages obtained by Kulp and others (see Geophys. Abs. 181-1) and confirm the fact that the results of Mayne and others (see Geophys. Abs. 176-1) are too high. There is a small systematic difference between the results obtained by the two techniques, but it is not large enough to be investigated easily at separate laboratories. The Cambridge apparatus is being modified to permit the use of both techniques on the same sample of gas.

It is concluded that the total volume technique can give good results on Paleozoic materials. In general, however, the isotopic dilution technique is preferable as its accuracy can be maintained for much younger samples. — D. B. V.

- 186-34. Dodson, M. H., and Moorbath, S. Isotopic ages of the Weardale granite: *Nature*, v. 190, no. 4779, p. 900, 1961.

The Rb-Sr and K-Ar ages have been determined on muscovite from Weardale granite recovered from a borehole in West Durham, England. The results all agree within limits of error. The weighted mean of $362 \pm 6 \times 10^6$ yr (Middle or Late Devonian) must correspond closely to the true age and supports the borehole evidence for a pre-Carboniferous age. This granite, therefore, is not connected with the Pennine mineralization ($280 \pm 30 \times 10^6$ yr) (see *Geophys. Abs.* 177-8) and is significantly younger than the Shap granite. — D. B. V.

- 186-35. Miller, J[ohn] A., and Green, D. H. Preliminary age determinations in the Lizard area: *Nature*, v. 190, no. 4784, p. 159-160, 1961.

A petrological examination of the Lizard Peninsula area in Cornwall, England, has led to an attempt to date the igneous and metamorphic assemblages by the K-Ar method. Measurements were made on 4 muscovites from the Old Lizard Head series and 2 biotites from the Kennack gneiss. The ages obtained are not consistent with the established sequence of geological events. The results are interpreted as follows: the mean age of 391×10^6 yr for the Kennack gneiss is the true age of the intrusion (Caledonian); the mean age of 356×10^6 yr for the Old Lizard Head series, the oldest rock in the area on geological evidence, reflects loss of argon due to retrograde metamorphism during later (Hercynian?) thrusting. — D. B. V.

- 186-36. Owen, T. R. Age of the orogeny and granites in south-west England: *Nature*, v. 191, no. 4787, p. 486, 1961.
Butcher, N. E. Age of the orogeny and granites in south-west England: *ibid.* p. 486-487, 1961.

Owen maintains that Butcher's case for a very Late Carboniferous orogeny in southwest England and for a Permian granitic injection (see *Geophys. Abs.* 186-32) has not been proved. Evidence is cited to support an earlier (late Westphalian) age for the main deformation of the Devonian and Culm of Devon and Cornwall; the granite intrusions probably accompanied this deformation.

Butcher replies that the evidence cited by Owen does not necessarily support a late Westphalian age for the orogeny and granites; he prefers to correlate the main orogeny with that in adjacent regions to the north, in agreement with Kulp and others (see *Geophys. Abs.* 181-1), but agrees that the case has not been proved. — D. B. V.

- 186-37. Cobb, James C., and Kulp, J. Laurence. Isotopic geochemistry of uranium and lead in the Swedish kolm and its associated shale: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 226-249, 1961.

The uranium and lead concentration and isotopic composition in a variety of samples of kolm and associated black shale from the Peltura beds (Franconian stage) of the Upper Cambrian of Sweden have been determined by isotope dilution techniques. In addition Th^{230} , Ra^{226} , Pb^{210} and radon leakage values have been determined on certain samples. All samples show discordant U-Pb isotopic ages. It appears that two processes have been at work: selective removal of Pb^{206} , resulting from the movement of an intermediate member of the U^{238} - Pb^{206} series, and removal of bulk radiogenic lead. The absolute age of the formation is concluded to be greater than 500 million years with the most probable age near this lower limit. This is in good agreement with the latest results on the absolute geologic time scale. The stratigraph-

ically well-dated kolm cannot, however, be considered a calibration point in the absolute time scale. It does show that uranium-lead dating on bituminous shales will lead to minimum ages for these formations. — Authors' abstract

- 186-38. Byström-Askund, A[nne] M[arie], Baadsgaard, H[alfdan], and Folinsbee, R. E. K/Ar age of biotite, sanidine, and illite from Middle Ordovician bentonites at Kinnekulle, Sweden: *Geol. Fören. Stockholm Förh.*, v. 83, no. 1, p. 92-96, 1961.

Bentonite beds with excellent biostratigraphic control occur in the Middle Ordovician limestones and shales at Kinnekulle, Sweden. The bentonites consist mainly of illite-montmorillonite "mixed layer" clays. Datable biotites and zircons were recovered from the grit fraction from 3 beds and sanidines from 2. The 3 biotites give K-Ar dates averaging 440×10^6 yr and the sanidines 447×10^6 yr; their overall average of 444×10^6 yr is in good agreement with the 447×10^6 yr average age determined by Adams and others (see *Geophys. Abs.* 184-29), using the U-Pb method on zircon from Middle Ordovician bentonites in the Appalachians. This may be low; an average of 475×10^6 yr obtained by Adams and others (1958) using the Rb-Sr method has been accepted by Holmes for his revised time scale.

The illite yields an age of only 331×10^6 yr, probably because of argon loss by diffusion. — D. B. V.

- 186-39. Feyling-Hanssen, Rolf W., and Olsson, Ingrid. Five radiocarbon datings of post glacial shorelines in central Spitsbergen: *Norsk Geog. Tidsskr.*, v. 17, no. 1/4, p. 122-131, 1959-60; reprinted in *Norsk Polarinstitut Medd.*, no. 86, 9 p., 1960.

Radiocarbon dates on five shell samples from the Late Pleistocene stratigraphic sequence at Billefjorden, central Spitsbergen, are reported. The recorded dates are too few to give detailed information about land recovery in central Spitsbergen; however, when inserted in a height-time diagram based on the stratigraphic sequence previously worked out by Feyling-Hanssen (1955) the dates provide an important fact about the curve of shoreline displacement during Post Glacial time. The curve consists of steeply and gently dipping parts. In the early part the shoreline displacement was of the order of magnitude of 200 cm per century, whereas in the late part the rate was only 15-18 cm per century. Insertion of the stratigraphic units of Blytt-Sernander with radiocarbon dates based on the recent work of Nydal and of Olsson (see *Geophys. Abs.* 182-26, -28) into the diagram shows that the Sub-Recent period of central Spitsbergen is synchronous with the Sub-Atlantic; the Post Glacial Warm period is identical with the Post Glacial Warm period in Europe (Firbas, 1954) or the Postglacial Hypsithermal Interval (Deevey and Flint, 1957), embracing the Sub-Boreal, Atlantic, and Boreal (Blytt-Sernander); and the Post Glacial Temperate period is synchronous with the Pre-Boreal time. No samples have been dated for the oldest or late Glacial Cold period but it probably is of younger Dryas age. Shorelines occur in Billefjorden up to 90 m above sea level and probably the late Glacial Cold period coincides in part with Allerød time. — V. S. N.

- 186-40. Voytkovich, G. V., and Anokhina, L. K. O vozraste nekotorykh kompleksov gornykh porod krivoyrozhskego zheleznorudnogo rayona [On the age of some rock complexes of the Krivoy Rog iron ore district]: *Geokhimiya*, no. 2, p. 185-187, 1961.

The K-Ar ages of 8 rocks and minerals from the Krivoy Rog iron district in the Ukrainian S. S. R. are tabulated. Biotites from granitic rocks containing

xenoliths of magnetite-bearing quartzites from the Don gorge (Ingulets River) give ages of 1,900 and $1,930 \times 10^6$ yr. These ferruginous quartzites appear to be remnants of iron formations contemporaneous with the Krivoy Rog iron deposits.

An age of $2,150-2,200 \times 10^6$ yr for the Saksagan granites, obtained on whole rock samples, is in good agreement with the results of other investigations. The dark fraction of a diabase from the Frunze mine gives an age of 596×10^6 yr (Paleozoic); this agrees well with the age of basic volcanics in other parts of the Precambrian basement of the Russian platform. — D. B. V.

- 186-41. Komlev, L. V., Savonenkov, V. G., Kryukova, N. F., and Kuchina, G. N. Drevneyshiye porody dokembriya Ukrainy v izluchine Dnepra [The oldest Precambrian rocks of the Ukraine in the bend of the Dnieper]: Akad. Nauk SSSR Doklady, v. 129, no. 6, p. 1374-1377, 1959.

The results of 35 argon age determinations on micas from inclusions in the Dneprovsk migmatites are tabulated. Ages from $2,500-2,700 \times 10^6$ yr to $3,000 \times 10^6$ yr were obtained. The migmatites themselves are $1,900-2,000 \times 10^6$ yr old. Taken together with the results of earlier work, this indicates that the main magmatic complexes of the Ukraine were formed over a long interval of time, $1,500-2,100 \times 10^6$ yr. — D. B. V.

- 186-42. Vinogradov, A. P., Tugarinov, A. I., Zykov, S. I., and Stupnikova, N. I. O vozraste pegmatitov Stanovogo kompleksa [On the age of the pegmatites of the Stanovoy complex (with English abstract)]: Geokhimiya, no. 5, p. 383-391, 1960.

The results of lead isotope age determinations on 11 minerals (allanites, zircons, and monazites) from pegmatites cutting the metamorphic Stanovoy complex in the Stanovoy Range in the eastern U.S.S.R. are presented. The Pb^{207}/Pb^{206} age of $1,900 \pm 100 \times 10^6$ yr agrees with K/Ar ages obtained on micas and is probably the true age of the pegmatites. The minimum age of 430×10^6 yr, obtained from the Pb^{208}/Th^{232} ratio, indicates the lower limit of the last metamorphism. — D. B. V.

- 186-43. Ovchinnikov, L. N. K voprosu opredeleniya absolyutnogo vozrasta rudnykh mestorozhdeniy Urala [Problem of determination of the absolute age of the ore deposits of the Urals]: Geokhimiya, no. 6, p. 545-552, 1958.

The argon ages of 28 micas and feldspars from metasomatic rocks accompanying contact-metasomatic copper and iron deposits in the Ural Mountains are tabulated. Three metallogenetic epochs are recognized, reflecting stages of magmatic activity and definite phases of orogenesis: the Salair, $420-460 \times 10^6$ yr; the Caledonian, $320-360 \times 10^6$ yr; and the Hercynian (Harz), $248-270 \times 10^6$ yr. — D. B. V.

- 186-44. Zamyatin, N. I., Ivanov, A. I., Monich, V. K., and Nurlybayev, A. N. Absolyutnyy vozrast shchelochnykh porod Ishimskogo kompleksa v tsentral'nom Kazakhstane [Absolute age of alkalic rocks of the Ishim complex in central Kazakhstan]: Akad. Nauk Kazakh. SSR Izv. Ser: Geol., no. 1 (42), p. 15-20, 1961.

The igneous rocks of the Ishim complex occur in the right bank area of the Ishim River in the northwest part of central Kazakh S.S.R. The principal rock types are tuffs and porphyritic lavas; intrusive alkalic rocks; syenite,

lamprophyre, and pegmatite dikes; and granosyenite and alaskite micropegmatites. All of these belong to the same comagmatic series. The absolute age obtained on biotites from these rocks is 405-438 million years, which corresponds to the Devonian and is compatible with the pre-Early Carboniferous geologic age. The absolute age determined for whole rock specimens ranges from 5 to 15 percent lower than that obtained on biotite. — J. W. C.

- 186-45. Gerling, E. K., Yashchenko, M. L., Levskiy, L. K., and Ovchinnikova, G. V. *Opredeleniye vozrasta nekotorykh' slud po rubidiy-strontsiyevomu metodu* [Determination of the age of some micas by the rubidium-strontium method]: *Geokhimiya*, no. 6, p. 535-544, 1958.

This is virtually the same paper as published in *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Trudy*, 7th sess., p. 326-342, 1958 (1960) (see *Geophys. Abs.* 184-75). — D. B. V.

- 186-46. Shcherba, G. N., and Ivanov, A. I. *Po povodu vozrasta nekotorykh redkometal'nykh granitnykh intruziy tsentral'nogo Kazakhstana* [The age of certain rare-metal granitic intrusions in central Kazakhstan]: *Geokhimiya*, no. 6, p. 607-609, 1958.

Supplementary argon age determinations on samples of granites and their derivatives show that the latest massif of the leucocratic ore-bearing granites of the Akchatau are $240-280 \times 10^6$ yr old, and the latest granites of the Zhanet district are $207-243 \times 10^6$ yr old. These figures controvert the "incontrovertible" findings of Komlev and others, which assigned these ores to a later Caledonian rather than to the Harz cycle (see *Geophys. Abs.* 180-5), and agree better with the geologic evidence. — D. B. V.

- 186-47. Fiji Geological Survey Department. *Geochronology: Fiji Geol. Survey Dept. Ann. Rept. for 1960*, p. 7-8, 1961.

Lead-alpha age determinations on zircon of granitic rocks from various areas in Fiji are reported as follows: from Yavuna, Nausori Highlands, $560 \pm 65 \times 10^6$ yr; Tau, Malomalo, $85 \pm 10 \times 10^6$ yr; and Nakalavo, Sigatoka Valley, $100 \pm 10 \times 10^6$ yr. Geological evidence suggests that the Yavuna granite is not older than 50 million years and that the Tau and Nakalovo granites are not older than 25 million years. Results are being checked by the K/Ar method because of the possibility that zircon may have been picked up at depth by the granite. — V. S. N.

Miyake, Yasuo, and Sugimura, Yukio. Ionium-thorium chronology of deep-sea sediments of the western North Pacific Ocean. See *Geophys. Abs.* 186-603.

- 186-48. Saito, Nobufusa; Tatsumi, Tatsuo; and Sato, Kazuo. Absolute age of euxenite from Antarctica: *Antarctic Rec.*, no. 12, p. 31-36, 1961.

The $\text{Pb}^{206}/\text{U}^{238}$, $\text{Pb}^{207}/\text{U}^{235}$, $\text{Pb}^{208}/\text{Th}^{232}$, and $\text{Pb}^{207}/\text{Pb}^{206}$ ages were determined on euxenite found in pegmatite in a diorite gneiss from the Skallen district, Lützow-Holm Bay, Antarctica. Except for an abnormally low $\text{Pb}^{208}/\text{Th}^{232}$ age, the ages coincide well with each other giving an average value of 470 million years. The Rb-Sr age of biotite from the same locality was found to be about 500 million years. Absolute ages of other rocks and minerals from Antarctica, determined by many investigators and summarized in a table, fall into two groups: one at 500 million years that includes rocks from the east coast of Lützow-Holm Bay, the Mirnyy region, and the west side of

McMurdo Sound; and a second at 900-1,100 million years that includes rocks from the Knox and Budd Coasts. The occurrence in Antarctica of Paleozoic charnockites, long thought to be a characteristic rock type of the Precambrian, has been ascertained from absolute age determinations by several investigators. — V. S. N.

186-49. The Polar Record. Absolute age of Antarctic rocks: Polar Rec., v. 10, no. 68, p. 530-531, 1961.

A list of 51 age determinations by the argon method on Antarctic rocks is presented. It was compiled from papers by Ravich and others published in *Informatsionnyy Byulleten' Sovetskoy Antarkticheskoy Ekspeditsii*, nos. 19 and 20, 1960, and in *Akad. Nauk SSSR Doklady*, v. 126, no. 1, 1959 (see *Geophys. Abs.* 177-20.) — V. S. N.

186-50. Focken, C. M. Radiocarbon dating laboratory, Museum of Applied Science of Victoria: Australian Jour. Sci., v. 23, no. 4, p. 127-128, 1960.

The first three preliminary determinations by the new radiocarbon dating laboratory in Melbourne, Australia, have checked the reliability and revealed the accuracy limits of the present equipment. For a sample of wood dated in the New Zealand laboratory as $9,400 \pm 120$ yr, an age of $9,200 \pm 250$ yr was obtained as 1 atm pressure and an age of $9,000 \pm 250$ yr at 2 atm. Two samples from a red gum stump dated elsewhere as $8,300 \pm 210$ yr (outer ring) and $8,720 \pm 200$ yr (inner ring) gave a mean result of $8,220 \pm 160$ yr. Wood from the Roman ship at Lake Nemi, used as an interlaboratory check sample, gave a result of $2,290 \pm 100$ yr, to which should be added the industrial correction; other dates for this sample were spread over 200 yr with a mean of 2,000 yr. — D. B. V.

186-51. Geochron Laboratories. Bibliography of geochronology: Cambridge, Mass., Geochron Laboratories, Inc., 24 p., 1961.

A bibliography containing over 450 titles covering all aspects of geological age measurements relating to radioactivity is presented. All C^{14} work is excluded. — V. S. N.

Hoyle, F. The age of the galaxy. See *Geophys. Abs.* 186-66.

Kuroda, Paul K. The time interval between nucleosynthesis and the formation of the earth. See *Geophys. Abs.* 186-67.

Fisher, David E. Cosmic ray ages of the Treysa and Sikhote-Alin meteorites. See *Geophys. Abs.* 186-68.

Vilczek, Elise, and Wänke, H. The exposure age of the iron meteorites from Cl^{36} measurements. See *Geophys. Abs.* 186-69.

Stauffer, Heinz. Primordial argon and neon in carbonaceous chondrites and ureilites. See *Geophys. Abs.* 186-63.

COSMOGONY

186-52. McCrea, W. H. The origin of the solar system: Royal Soc. [London] Proc., v. 256, no. 1285, p. 245-266, 1960; *Origine du systeme solaire* [Origin of the solar system]: *Ciel et Terre*, v. 76, no. 11-12, p. 369-385, 1960; Formation of stars from interstellar matter: Soc. Royal Sci. Liege Mem., v. 3, p. 332-342, 1960.

A theory is presented that removes the classic "angular momentum difficulty" that besets most theories of star formation as well as theories of the origin of the solar system. Interstellar material in which stars are about to be formed consists of "flocules" moving at random among themselves and probably composed mainly of molecular hydrogen. The process producing condensations that grow into stars would also produce minor condensations in material that becomes trapped in the growing gravitational field of these stars to form planetary systems associated with the stars. Details of the theory account satisfactorily for the mass and number of the planets of the solar system and their rotation. — D. B. V.

- 186-53. Suworoff [Suvorov], N. P. Die Entstehung der Planeten des Sonnensystems [The origin of the planets of the solar system]: *Naturwissenschaften*, v. 48, no. 7, p. 214, 1961.

The planets originated between spectral type stages gF and dF of the sun's evolution, when the sun increased abruptly in mass and decreased in density and angular momentum, with concomitant drastic increase in gravitational acceleration at its surface and decrease in centrifugal force. Probably the flashing of a nova announces the formation of planets. The ages of the members of the solar system are tabulated as follows (in 10^9 yr): sun 4.67, Jupiter 2.05, Saturn 2.04, Uranus 2.03, Neptune 2.02, Pluto 2.01, asteroids 1.95, Mars 1.94, Earth 1.91, Venus 1.90, and Mercury 1.88. — D. B. V.

- 186-54. Omori, Keiichi. Abrupt changes of physical conditions of the earth-surface by the passing of a large star: *Tohoku Univ. Sci. Repts.*, ser. 3, v. 7, no. 1, p. 131-151, 1961.

Omori has proposed (see *Geophys. Abs.* 182-60) that saline deposits are formed as a result of sudden drastic changes in the rotation and revolution of the earth due to the passing of large stars. The sudden change in temperature and physical conditions of the earth's surface would also affect animal and plant life, and cause the revolutions of geologic history. In this paper, the distances of passing stars from the earth and the dates of their passing are calculated for 1,026 stars described in Schütte's table. Results, which are tabulated, show good agreement of the geologic epochs in general with the passage of relatively close stars. — D. B. V.

- Lomnitz, C[inna]. On thermodynamics of planets. See *Geophys. Abs.* 186-123.

- 186-55. Fisher, David E. Origin of stone and iron meteorites: *Nature*, v. 1901, no. 4772, p. 244-245, 1961.

One line of experimentation bearing on the question of whether stone and iron meteorites had a common origin is the determination of their cosmic-ray exposure ages. A recent compilation of available exposure age calculations by Urey (see *Geophys. Abs.* 179-30) suggests that the stones and irons may have had a different origin and history. Uncertainties concerning helium production rates, their dependence on depth, and the effect of space erosion are discussed, and it is concluded that until further information is available on more direct radioactive-stable nuclide determinations (such as Ar^{38}/Ar^{39} , H^3/He^3), the postulation of separate origins for stone and iron meteorites is not justified. — D. B. V.

- 186-56. Dingle, Herbert. The frequency of meteorite falls throughout the ages: *Nature*, v. 191, no. 4787, p. 482, 1961.
 Pettersson, Hans. The frequency of meteorite falls throughout the ages: *ibid.*

Dingle points out that the presence of cosmic spherules in Tertiary sediments reported by Pettersson (see *Geophys. Abs.* 184-83) is not inconsistent with the assertion that no meteors fell at the time; evidence is lacking that meteors and meteorites have a common origin.

Pettersson replies that the structure of cosmic spherules definitely supports the interpretation that they were derived from nickel-iron meteors heated to superficial melting during flight through the atmosphere and that they might also be derived from meteorites. Whether meteorites and ordinary meteors are of different origin is still an open question (Whipple assumes that most meteors are of cometary origin, whereas meteorites are usually assumed to be derived from planetary fragments like the asteroids). — D. B. V.

- 186-57. Ringwood, A. E. Chemical and genetic relationships among meteorites: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 159-197, 1961.

Optical and X-ray studies of olivines, pyroxenes, and metal phases from 34 chondrites for which chemical analyses are available confirm the fact that chondrites are samples of a homogeneous parent material which varied widely in its state of oxidation. The original state probably resembled that displayed by the carbonaceous chondrites. Primary chondritic textures are tuffaceous in nature and therefore of volcanic origin. Chondrites have subsequently been exposed to varying degrees of metamorphism, causing compaction and recrystallization; the range of pressures indicated is such that at least one of the parent bodies must have been of lunar size.

The genesis of other groups of meteorites can be explained in terms of melting and differentiation of a small amount of parental chondritic material. The irons probably crystallized under high pressures (more than 30,000 atm) near the center of a parent meteoritic planet about 4.5×10^9 yr ago. Subsequent cooling below 450°C occurred within about 10^8 yr. Cooling of the small molten core of the planet occurred by adiabatic heat exchange with the outer chondritic mantle, which had been rapidly cooled to about 300°C during the endothermic volcanic phase of evolution. The meteoritic planet(s) broke up less than 10^9 yr after melting and differentiation, and the fragments have since been colliding and becoming reduced in size, forming the asteroids. — D. B. V.

- 186-58. Nomoto, Morikazu. Physical theory of meteor: *Tohoku Univ. Sci. Repts.*, ser. 1, v. 43, no. 4, p. 245-259, 1959.

The action of the atmosphere on a meteor is studied by treating the effect of the impact of individual atoms and molecules of the atmosphere on the meteor surface. Radiation damage occurs on the inside of the surface, and the average of the heat-transfer rate over the surface is estimated to be about 0.81, assuming that the surface is roughly spherical. Assuming that the medium of the meteor is continuous and making use of Mitra's data for the density of the atmosphere, variations of the meteor velocity, radius, and temperature with height are found to be functions of the initial velocity, dimension, and angle of incidence. The appearance and disappearance heights are estimated as functions of the same initial quantities, and the values are quite reasonable in comparison with observed data. — V. S. N.

- 186-59. Goles, Gordon G., and Anders, Edward. On the geochemical character of iodine in meteorites: *Jour. Geophys. Research*, v. 66, no. 9, p. 3075-3077, 1961.

The results of leaching experiments, abundance determinations on troilite and metal phases from iron meteorites, and analysis of mechanically separated

fractions of a chondrite suggest that oldhamite is the host mineral for iodine in chondrites. If this identification is valid, the iodine must have been subjected to rather extensive chemical processing after its incorporation in the meteorite parent bodies, as oldhamite could not have been present in the primordial nebula as such. The process would have resulted in the strong fractionation of iodine from any Xe^{129} that had accumulated in the primordial iodine-bearing grains.

A direct test is possible to determine whether the fractionation occurred in the primordial nebula rather than in the meteorite parent bodies. If no significant excess Xe^{129} is found in the water-soluble or fine fractions of appropriate meteorites, then I-Xe decay intervals may well refer to events in the primordial nebula (see Geophys. Abs. 183-71, 184-90), but if the excess Xe^{129} is largely in iodine-rich fractions, then I-Xe decay intervals probably refer to the cooling of the meteorite parent bodies (see Geophys. Abs. 185-95). — D. B. V.

- 186-60. Lipschutz, Michael E., and Anders, Edward. The record in the meteorites—4. Origin of diamonds in iron meteorites: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 83-105, 1961.

Study of a number of diamond-bearing specimens of the Canyon Diablo meteorite indicates that the diamond-bearing specimens, and only these, were reheated strongly after formation of the Widmanstätten pattern. The metal phase appears to have been reheated to about 950°C for 1-5 sec, and then cooled in less than 2 min. The rapid cooling rate implies that the process took place after the meteorite fragments had attained their present small size. Thermodynamic calculations and structural studies severely limit the range of possible conditions for diamond formation in meteorites.

It is considered likely that all meteoritic diamonds were produced by catastrophic events, either upon impact with the earth or during the breakup of parent bodies. This mode of origin obviates the need for postulating parent bodies of lunar or planetary dimensions with interior pressures of 3×10^4 atm or greater. — D. B. V.

- 186-61. DuFresne, E. R., and Roy, S[harat] K[umar]. A new phosphate mineral from the Springwater pallasite: *Geochim. et Cosmochim. Acta*, v. 24, no. 3/4, p. 198-205, 1961.

Farringtonite, a new anhydrous magnesium phosphate mineral, has been found in contact with iron in the Springwater pallasite meteorite. From the physical properties and chemical reactions of the two phases it can be inferred that cooling through the freezing range was rapid. This seems to rule out ideas involving a deep-seated environment within a planet as the source of pallasites. The optical, physical, chemical, and X-ray properties of the mineral are given. — D. B. V.

- 186-62. Eberhardt, P[eter], and Eberhardt, A. Ne in some stone meteorites: *Zeitschr. Naturforschung*, v. 16a, no. 3, p. 236-238, 1961.

The $\text{Ne}^{21}/\text{Ne}^{22}$ and $\text{Ne}^{20}/\text{Ne}^{22}$ ratios and the Ne^{21} content of 8 stone meteorites (4 chondrites, 3 achondrites, and 1 pallasite) were measured. Good agreement with other cosmic-ray-produced rare gas isotopes was obtained. None of the chondrites showed an excess of Ne^{20} . The Novo Urei achondrite, a ureilite, shows a high $\text{Ne}^{20}/\text{Ne}^{21}$ ratio; this certainly could be interpreted as primordial gas, but the possibility of absorbed atmospheric Ne cannot be excluded in the case of this particular meteorite as it is very porous. — D. B. V.

- 186-63. Stauffer, Heinz. Primordial argon and neon in carbonaceous chondrites and ureilites: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 70-82, 1961.

Measurements of the abundance and isotopic composition of argon and neon in 5 carbonaceous chondrites and 2 ureilites show that these meteorites contain large amounts of trapped primordial gases. At 950°K the radiogenic argon diffuses out more readily than primordial argon, and cosmogenic neon at about the same rate as primordial neon. From this it is concluded that the primordial gases are enclosed within the matrix of the crystal lattice.

K-Ar ages and Ne²¹ exposure ages are calculated. Both are affected by diffusive losses; only Felix has a K-Ar age of 4.5×10^9 yr.

A large loss of primordial argon and neon compared to silicon is observed. The loss of primordial argon is constant within a factor of 10 and is about 10-100 times smaller than the loss observed for the earth. The ratios of primordial Ne²⁰ to primordial Ar³⁶ range between 0.005 and 22, indicating large fractionation between argon and neon compared to the corresponding cosmic ratio. Fractionation by diffusive losses is discussed. Some deviations of the isotopic ratios of primordial argon and neon from the atmospheric ratios are observed. — D. B. V.

- 186-64. Levskiy, L. K. Inertnyye gazy v dvukh zheleznikh meteoritakh [Inert gases in two iron meteorites]: *Geokhimiya*, no. 2, p. 183, 1960.

The Ar and He isotopic compositions and ratios in the Chebankol and Chinge iron meteorites are tabulated and compared with published data on the Sikhote-Alin and Toluca meteorites (see *Geophys. Abs.* 179-269, 168-201). The He³/He⁴ and He³/Ar³⁸ ratios are considerably lower in Chinge than in the other three meteorites. — D. B. V.

- 186-65. Anders, Edward. Extinct radioactivity and the prehistory of the solar system: *Zeitschr. Naturforschung*, v. 16a, no. 5, p. 520-521, 1961.

Some of the implications of Murthy's discovery of Ag¹⁰⁷ from the decay of Pd¹⁰⁷ in the Toluca iron meteorite (see *Geophys. Abs.* 184-99) are pointed out. It is shown that the high abundance of Pd¹⁰⁷ (an amount of the order of 10^{-3} has been observed) is wholly inconsistent with the formation interval (Δt) of 10^8 yr inferred from the longer-lived nuclides Pb²⁰⁵, I¹²⁹, and Pu²⁴⁴. If the presence of excess Ag¹⁰⁷ is confirmed, either Δt must be lengthened for longer-lived nuclides, or the amount of Pd¹⁰⁷ must be increased above predicted levels.

The Δt 's for I¹²⁹ and Pu²⁴⁴ refer to the cooling of the meteorite parent bodies and planetesimals, and hence need not agree with those obtained for Pd¹⁰⁷ and Pb²⁰⁵. The Δt 's for Pd¹⁰⁷ and Pb²⁰⁵ are not necessarily in conflict with each other, as the latter is rather uncertain. If these factors cannot account for the discrepancy, it may be necessary to look for processes that will produce Pd¹⁰⁷ in preference to the longer-lived nuclides. Possible reactions are suggested. Fortunately the problem can be studied experimentally, as each nuclear process gives rise to its own distinct abundance pattern. — D. B. V.

- 186-66. Hoyle, F. The age of the galaxy: *Royal Soc. [London] Proc.*, v. 260, no. 1301, p. 201-204, 1960.

Evidence recently obtained from two quite independent sources suggests that the age of our galaxy is at least as great as 1.5×10^{10} yr. It has been

suggested that the age might be as high as 2.5×10^{10} yr, a value some five times greater than estimates quoted half a decade ago. — Author's abstract

- 186-67. Kuroda, P[aul] K. The time interval between nucleosynthesis and the formation of the earth: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 40-47, 1961.

The differences (δ_i) in the abundance ratios of the stable xenon isotopes in meteorites and in the earth's atmosphere indicate that the latter contains an excess of fissionogenic xenon. It is postulated that extinct transuranium elements such as Pu^{244} and Cm^{247} played important roles in the production of fissionogenic xenon in the atmosphere. The time interval between nucleosynthesis and the formation of the earth has been calculated from the values of δ_i as 4.8×10^8 yr for the single event model and 0.52×10^8 yr for the continuous synthesis model. — D. B. V.

- 186-68. Fisher, David E. Cosmic ray ages of the Treysa and Sikhote-Alin meteorites: *Nature*, v. 190, no. 4772, p. 225-227, 1961.

The suggestion that the cosmogenic production rate, dependent on depth, of stable nuclides in iron meteorites can be estimated from the measured rare gas ratios (see *Geophys. Abs.* 182-73, 183-65) has been criticized (see *Geophys. Abs.* 185-93) because it assigned different exposure ages to the Sikhote-Alin and Treysa meteorites, whereas direct measurements lead to approximately equal ages (see also *Geophys. Abs.* 182-64, 183-62). Reexamination of the data has shown an error in calculation of the He^3 production rate in Treysa; the corrected scheme of the apparent correlation between radioactivity and rare gas content is shown in a graph that includes new data on the He^3 content of Treysa and Sikhote-Alin. The scheme does not account for the Ar^{39} data on Treysa nor for the He^3 data on Sikhote-Alin.

Exposure ages for Treysa and Sikhote-Alin have been recalculated using all available raw data on rare gas, He^3 , Sc^{45} , and Cl^{36} measurements. The spread in ages reflects both the different experimental values for measurements of the same nuclide in the same meteorite by different investigators and the uncertainty in the necessary assumptions. The ages proposed as "best" are 0.16×10^9 yr for Sikhote-Alin and either 1.3×10^9 yr (based on the graph of nuclide production rate) or 0.35×10^9 yr (based on Ar^{39} data) for Treysa. — D. B. V.

- 186-69. Vilczek, Else, and Wänke, H. Das Strahlungsalter der Eisenmeteorite aus Chlor-36-Messungen [The exposure age of the iron meteorites from Cl^{36} measurements (with English abstract)]: *Zeitschr. Naturforschung*, v. 16a, no. 4, p. 379-384, 1961.

The Cl^{36} produced by cosmic ray particles with nuclei in meteorites was measured in 1 stone and 7 iron meteorites. The decay rate for Cl^{36} in the iron meteorites was 6.5-20.2 disintegrations per minute per kilogram. Exposure ages calculated from these values and from concentrations of stable spallation products were close to 500×10^6 yr for 6 of the meteorites; Sikhote-Alin, however, gave an age of 60×10^6 yr, considerably lower than the age found by others for the same meteorite. It is suggested that Sikhote-Alin was part of a larger meteorite that broke up about 60×10^6 yr ago on collision with another meteorite. — D. B. V.

- 186-70. Millman, P. M., Liberty, B. A., Clark, J. F., Willmore, P. L., and Innes, M. J. S. The Brent Crater: Dominion Observatory Ottawa Pubs., v. 24, no. 1, 43 p., 1960.

Brent Crater, located in Algonquin Park, Ontario, was first observed on aerial photographs as a circular depression approximately 2 miles in diameter. Geological investigations indicate that the circular area is underlain by Paleozoic sediments whereas the surrounding country rock is mainly granite gneiss; magnetic investigations that the crater is filled with material of lower magnetic susceptibility than the surrounding rock; seismic observations that the crater contains up to 1,000 feet of fairly soft rocks, and perhaps 3,000 feet of other material in which seismic waves travel more slowly than in the surrounding gneiss; and gravity observations that the crater is filled with material of relatively low density to a depth of from 1,500 to 4,000 feet depending on assumptions concerning the average density contrast. A diamond drill hole near the center penetrated a depth of 570 feet of Paleozoic sediments, and a second hole near the edge revealed the presence of large quantities of breccia. It is concluded that the crater was formed by the impact of a meteorite, possibly in late Precambrian time, and that its present state is a consequence of subsequent erosion and the deposition within it of Paleozoic sediments. — V. S. N.

- 186-71. Dietz, Robert S. Vredefort ring structure: Meteorite impact scar?: *Jour. Geol.*, v. 69, no. 5, p. 499-516, 1961.

It is suggested that the Vredefort ring structure of South Africa is a meteorite impact structure. It was found that an asteroid 2.3 km in diameter with an impact velocity of 20 km/s would provide the 6×10^{28} ergs needed to create the original crater 40 km across and 16 km deep. The theory adequately explains: (1) the apparent impulse direction; (2) the shatter cones as shock induced; (3) the bilateral symmetry as produced by oblique impact; (4) the upturned and tilted 16 km-thick collar as the effect of radial forces spreading out from the explosion focus; (5) the pressure and thermal metamorphism of the sedimentary collar; (6) the intensive fracturing and micro-shearing of the rock as shock-wave induced; (7) the pseudotachylite as "shock impactite"; and (8) the granophyre dikes as injected crater-lining "impactite". The uplifted granite plug now filling the crater was caused by a combination of elastic rebound and isostatic forces. — V. S. N.

- 186-72. Donati, Gemmarosa Levi. Catalogue of the meteorites in the mineralogical collection of the University of Modena (Italy): *Accad. Naz. Sci. Lettere e Arti Modena, Atti e Mem.*, ser. 6, v. 2, 4 p., 1960.

The meteorite collection of the University of Modena, Italy, consists of 40 specimens and small fragments, totaling about 2 kg, that represent 26 different falls in various parts of the world. The collection is listed in 5 tables according to type of meteorite—chondrites, achondrites, sideraerolites, lithosiderites, and octahedrites. — V. S. N.

- 186-73. Dey, A. K. The Valudavur meteorite: *India Geol. Survey Recs.*, v. 86, pt. 3, p. 447-454, 1960.

A meteorite weighing about 2,799 g and more or less rhomboidal in shape fell at Valudavur, 10 miles northwest of Pondicherry, South Arcot district of Madras, India, on October 30, 1944. The Valudavur meteorite is a chondritic stony meteorite that resembles the Kroonstad meteorite in general appearance and chemical composition, and is, therefore, classified as a bronzite chondrite. — V. S. N.

- 186-74. Hemenway, Curtis L., Fullam, Ernest F., and Phillips, Laurence. Nanometeorites: *Nature*, v. 190, no. 4779, p. 897-898, 1961.

High-altitude airborne particles collected in the Arctic by a U-2 aircraft at 60,000 feet included enormous numbers of ultra-small high density particles of the order of 75 Å, in addition to the solid and "fluffy" particles larger than 0.2 μ normally seen in previous collections from somewhat lower altitudes. Study of these extremely small particles and the background material by selected-area electron diffraction suggests that they represent a previously unsuspected class of meteorite bodies entering the atmosphere. As they are about a thousand times smaller in diameter than micrometeorites, and as the forces acting on them probably are critically dependent on their electric charge and velocity in the ionosphere and geomagnetic field, it is proposed that they be called "nanometeorites." A lunar dust origin is favored, but they could in part result from meteor ablation or fragmentation. A full report is forthcoming. — D. B. V.

- 186-75. Laevastu, Taivo, and Mellis, Otto. Size and mass distribution of cosmic dust: *Jour. Geophys. Research*, v. 66, no. 8, p. 2507-2508, 1961.

The size distribution of the cosmic spherules found in sediments shows that the total mass of particles in equal size (diameter) intervals remains constant. The size distribution of cosmic dust in space, as computed from the data obtained by impact measurements by artificial satellites, shows the same distribution in the interval of particle diameters approximately 5 μ and 15 μ , and as determined by indirect extrapolation the distribution is probably valid for larger particles. — Authors' abstract

- 186-76. Dubin, Maurice. Remarks on the article by A. R. Hibbs, "The distribution of micrometeorites near the earth": *Jour. Geophys. Research*, v. 66, no. 8, p. 2592-2594, 1961.
Hibbs, A. R. Author's reply to the preceding discussion on the article, "The distribution of micrometeorites near the earth": *ibid.*, p. 2595-2596, 1961.

Dubin states that Hibbs' analysis of the Explorer I micrometeorite data (see *Geophys. Abs.* 184-82) was incorrect. There were only 145 type A impacts recorded without redundancy, and these include 66 impacts from a cosmic dust "shower"; the Poisson distribution would not be valid for such a sample and is inconsistent with the large variation of daily impact rate.

Hibbs replies that he arrived at 166 valid nonredundant impact recordings from a review of the original data tapes, but that differences between his and Dubin's conclusions cannot be ascribed to this difference. Even if the "shower" impacts are removed completely, the strong altitude effect is still displayed, and the data still show the closed-orbit phenomenon. The apparent diurnal variations in flux rate are more than adequately accounted for on the basis of orientation of the satellite trajectory. — D. B. V.

- 186-77. Crozier, W. D. Micrometeorite measurements—satellite and ground-level data compared: *Jour. Geophys. Research*, v. 66, no. 9, p. 2793-2795, 1961.

Comparison is made between an annual mass accretion to the earth (3.9×10^5 metric tons) calculated on the basis of micrometeorite counts by satellites 1958 α and 1959 η , and an annual mass accretion of magnetic spherules (0.9×10^5 metric tons) determined by collections made at ground level by the Airborne Particle Study of the New Mexico Institute of Mining and Technology. Both measurements apply to the particle mass interval 3.3×10^{-10} g to 1.2×10^{-8} g. On the basis of the theory of Öpik [1951, 1956] the ratio of the two amounts is

quite reasonable, but the entire interpretation becomes uncertain because of the possibility that many of the particles encountered by the satellites may be in orbit around the earth. — Author's abstract

- 186-78. Hodge, Paul W. Sampling dust from the stratosphere: *Smithsonian Contrib. to Astrophysics*, v. 5, no. 10, p. 145-152, 1961.

Of the meteoric objects that enter the earth's atmosphere from interplanetary space, the smallest and most numerous are dust particles. In order to obtain meteoritic dust from places where contamination by terrestrial dust is as slight as possible, 45 filters were flown in collectors mounted on high-altitude jet aircraft. Study of this stratospheric dust shows that at 45,000 feet there are approximately 30 particles $>6\mu$ in diameter per cu m; there is evidence that these particles are unevenly distributed in space at this altitude. Most of the particles are transparent or semitransparent and are probably of terrestrial origin. Space density of opaque particles at 45,000 feet is roughly two particles $>3\mu$ in diameter per cu m, and there is no convincing evidence that any large percentage of these particles is extraterrestrial in origin. Comparison of the number of particles found at 45,000 feet with the number found at sea level indicates that many opaque, probably high-density particles are carried up into the stratosphere. — V. S. N.

- 186-79. Fireman, E. L., and Kistner, G. A. The nature of dust collected at high altitudes: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 10-22, 1961.

Analysis of dust collected from the atmosphere at altitudes above 40,000 feet indicates that very few particles occur with nickel and cobalt concentrations similar to those in iron meteorites. Deep-sea spherules are therefore probably produced by friction during the passage of larger iron meteorites through the atmosphere. An upper limit of 30,000 tons per yr for the entire earth is calculated for the accretion rate of particles between 3μ and 30μ in size with an Fe-Ni-Co ratio similar to that of meteorites. Many of the particles could represent possible terrestrial contamination, but this explanation is improbable for the iron-manganese particles. — D. B. V.

- 186-80. Kaiser, T. R. The incidence of interplanetary dust [with French and Russian abstracts]: *Annales Géophysique*, v. 17, no. 1, p. 50-59, 1961.

Interplanetary dust can be investigated in a number of ways; these include optical and radio meteor observations, the collection at the earth's surface of accreted particles, the scattering of sunlight (the zodiacal light), as well as more direct observations with rocket and satellite borne instruments. This paper treats in some detail the reduction of radio-echo data to yield the absolute incident meteor flux. Observational data obtained by the various techniques listed above are presented, and the problems in reconciling them are discussed. — Author's abstract

- 186-81. Barnes, Virgil E. A world wide geological investigation of tektites: *GeoTimes*, v. 6, no. 2, p. 8-12, 38, 1961.

A brief account is given of a systematic and coordinated field examination of localities where tektites and other natural glasses occur. Six months were spent visiting most of the tektite-strewn fields, some meteorite craters with glass around them, tektite collections in museums, and workers on tektites and meteorites in England, Russia, Czechoslovakia, Egypt, Saudi Arabia,

India, Malay, Singapore, Australia, Indonesia, Thailand, Cambodia, South Viet Nam, and the Philippines. A few areas (Ivory Coast, Libyan Desert, Mauretania, and Peru) remain to be visited, but it is possible that the data and samples already collected may provide sufficient evidence to prove the terrestrial or extraterrestrial origin of tektites. — V. S. N.

- 186-82. Vorob'yev, G. G. O khimicheskom sostave tektitov v svyazi s problemoy ikh proiskhozhdeniya [On the chemical composition of tektites in relation to the problem of their origin (with English abstract): *Geokhimiya*, no. 5, p. 427-442, 1960.

The average composition of tektites, silica glasses, and impactites has been calculated on the basis of more than 100 published chemical analyses. The chemical character of the individual groups (moldavites, indochinites, philippinites, billitonites, Java tektites, australites, Ivory Coast tektites, bediasites, americanites, livites, tasmanites, and impactites) is also established. The distinctly hybrid character of tektites as a whole suggests that they are probably of cosmic origin. — D. B. V.

- 186-83. Watson, Kenneth, Murray, Bruce C., and Brown, Harrison. The behavior of volatiles on the lunar surface: *Jour. Geophys. Research*, v. 66, no. 9, p. 3033-3045, 1961.

A detailed theory of the behavior of volatiles on the lunar surface, based on solid-vapor kinetic relationships, is presented, according to which water should be far more stable there than the noble gases or other possible constituents of the lunar atmosphere. Numerical calculations indicate that the amount of water lost from the moon since the present surface conditions were initiated is only a few g per cm² of the lunar surface. The amount of ice eventually detected in lunar "cold traps" will thus provide a sensitive indication of the degree of chemical differentiation of the moon. — D. B. V.

- 186-84. Alter, D[insmore]: Evolution of the moon: *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 1-6, 1960.

After a discussion of the George Darwin theory of the origin of the earth-moon system and of the widely accepted protoplanet hypothesis, it is suggested that the hypothesis of the capture of a small independent rigid planet more nearly meets the conditions found in the earth-moon system today. The original conditions that could have resulted in the present system would be: a moderately rapid initial rotation of the captured planet, preferably approaching the month; a first perigee not too much within a 1,000-mile surface distance; and a moderate orbital eccentricity. The skew distribution of the mare areas on the moon is further evidence of capture; if tidal forces quickly pinned the rotation of the moon and caused the maria, the concentration as found today toward the preceding limb with a general east-west spread due to libration would be expected. If bombardment caused the maria, the far side should have approximately the same mare areas as the near side; moreover, the earth should have shielded the near side from solar asteroids. The great, bright mountainous areas of the southern and southwestern parts of the near side approximate somewhat the original surface of the moon. Truly sharp pictures of the far side should show even greater numbers of these precapture features. — V. S. N.

- 186-85. Shoemaker, E[ugene] M. Ballistics of the Copernican ray system: *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 7-21, 1960.

The one major feature of lunar craters observable from the earth that may permit discrimination of impact craters from volcanic craters is the distribution pattern of the ejecta. Ejecta from maar-type volcanoes are thrown out along high angle trajectories and shower down in a diffuse, more or less uniform pattern around the crater. Ejecta from large impact craters are thrown out along both high and low trajectories. Many lunar craters are surrounded by a system of rays resembling the ejecta patterns around nuclear- and high-explosion craters. The ray pattern of Copernicus is analyzed in detail. In order to reduce the ballistic problem of the Copernican rays to a series of discrete points that can be treated mathematically, a compilation of 975 secondary impact craters was made. To find trajectories for individual fragments ejected from Copernicus a theory of cratering that gives the relation between ejection velocities and angle of elevation of ejection is required. A series of approximations and an idealization of the cratering problem is used to obtain a relation in closed algebraic form. Results indicate that the bolide that formed Copernicus was probably an independent member of the solar system and not a planetesimal or moonlet orbiting the earth. Moreover, a simple genetic relationship between the main features of the Copernican ray pattern and other observable features of the lunar crust is found by use of the idealized theory of cratering; the theory accounts quantitatively for both the crater dimensions and the distribution of the ejecta. The formation of chains and compound secondary craters is a lesser manifestation of the phenomenon of the fragment clustering which is responsible for the formation of the rays. — V. S. N.

- 186-86. Salisbury, J. Origin of lunar domes: Lunar and Planetary Explor. Colloquium Proc., v. 11, no. 2, p. 22-26, 1960.

The three existing hypotheses for explaining the origin of lunar domes—shield-volcano, lava-bubble, and laccolith—are reviewed, and a new hypothesis—mineral phase change expansion—is suggested. Mineral phase change expansion could produce the domes observed on the moon, whether large or small, regular or irregular, cratered or uncratered. The apparent restriction of domes to the lava plains can be explained as the result of a restriction to areas where water vapor leakage might be at a maximum. — V. S. N.

- 186-87. MacDonald, G. J. Seismic activity of the moon: Lunar and Planetary Explor. Colloquium Proc., v. 11, no. 2, p. 45-47, 1960.

Various models of the moon were constructed to investigate possible natural seismic activity. Assuming a moon of the composition of a chondritic meteorite 4.5 billion years ago, and with an initial temperature of 0°C , then over the last billion years and at the present, strain energy would be released at a rate of 1×10^{25} ergs per year. If the moon were initially cold and has been steadily heating up due to radioactivity, and if the principal mechanisms of heat transfer are conduction and radiation, the present rate of strain energy release would be about equal to or greater than that for the earth. If the moon were initially at a higher temperature and there were different mechanisms of heat transport, the present rate of strain energy release would be less per unit area than for the earth. Additional calculations were made for varying distributions of radioactivity. Regardless of the radioactivity and thermal expansion coefficients within the lunar material, the models of the lunar history would seem to indicate a constant surface area and a constant radius. The model studies thus suggest that large horizontal movements, such as are observed on the earth, have not taken place on the moon. — V. S. N.

- 186-88. Gilvarry, J[ohn] J. Origin and nature of lunar surface features: Nature, v. 188, no. 4754, p. 886-891, 1960.

It is shown that the origin and nature of the major surface features of the moon can be explained in terms of the former presence of a lunar hydrosphere. It is calculated that this hydrosphere lasted 1 billion years. The level floors of the maria were formed by sediments deposited from the water in the course of dissipation. The relative dimensions of the lunar craters can be explained by the progressive change in depth of the water, in which meteors exploded to form the craters.

The theory further has a direct bearing on the origin of tektites, as it provides argillaceous sediments and quartz particles of the necessary chemical composition. The dark color of the maria could be due to a small amount of organic carbon furnished by a postulated primitive form of life that existed in the lunar hydrosphere. The pattern of light and dark color in the mare basins, following the retreat of the seas, is a positive clue that life once existed there. The inferred presence of organic carbon would also easily explain Kozyrev's observation (see *Geophys. Abs.* 177-368) as the result of sublimation of carbon by the heat of a meteorite impact. — D. B. V.

- 186-89. Warner, Brian. Holistic approach to selenology: *Nature*, v. 191, no. 4788, p. 586, 1961.

The limitation to both the impact and the volcanic theories of formation of the lunar craters is that neither distinguishes between primary and secondary features of the lunar surface. Consideration of the lunar grid system shows that large-scale stresses have been applied to the surface during its history and have obliterated information pertinent to the origin of the craters. In addition, completely new types of features have arisen, such as rill and valley systems, some of which have erroneously been interpreted as primary features. When it is accepted that the valleys radial to the Mare Imbrium are nothing more than a slightly more prominent element of the general grid system, the collision hypothesis for the origin of the moon loses considerable weight. — D. B. V.

- 186-90. Jastrow, Robert. The exploration of the moon: *Sci. American*, v. 202, no. 5, p. 61-69, 1960.

Exploration of the moon may yield answers to fundamental questions about the nature and origin of the solar system and the universe at large. Such exploration is more important than that of other planetary bodies because of the moon's dead and changeless nature unaffected by processes of erosion and mountain building. Cosmic dust, unimpeded by atmosphere, has rained for eons to produce a biographical record of the solar system. Evidence on the temperature history of the moon will settle many questions as to the origin of the sun and planets, and measurements of irregularities in shape and of the distribution of density in the moon will be of help in this respect. More detailed pictures of the surface than those obtainable from the earth are necessary to help explain the nature of the surface features. Seismometers, X-ray fluorescence spectographs, gravimeters, ionosphere and plasma probes, density gauges, magnetometers, and television cameras landed by unmanned space vehicles and controlled from the earth will be used within a few years for exploration. The ultimate in unmanned craft may be a roving vehicle piloted by remote control. With the advent of manned flights, a decade or more hence, lunar exploration will enter upon its most rewarding phase. — V. S. N.

- 186-91. Brereton, Roy G. The lunar surface: *Geotimes*, v. 6, no. 2, p. 22-26, 1961.

The development of the constructional landforms of the moon is discussed from the viewpoints of the two contrasting theories of catastrophism—meteor

impact or a molten moon with consequent violent and global evolution of gases. Meteor impact has probably played an important part in the development of the lunar surface, but the formation of the diverse and grand constructional land-forms displayed on the surface, and the division of the moon into dark-colored depressed areas (mares) and lighter-colored elevated areas (continents) is more likely related to an internal, fundamental magmatic process associated with the moon's early thermal history. The chief sources of heat available for heating the primal moon include radioactivity, meteor aggradation, and gravitational compaction. Secondary heat sources—meteor impact and faulting—triggered the near-surface magmatic phase that formed the lunar continents and mares, and contributed to the genesis of the whole lunar surface. The sequence of events relating to the thermal history of the moon is described in a table. It seems probable that an eruptive-lava complex composes most of the lunar surface and forms the bedrock that underlies more recently formed fragmental rocks and meteor dust. Because of the absence of a completed orogenic and weathering cycle on the moon, phanerocrystalline rocks will not be found exposed at the surface. The properties of the lunar surface are given in a table. The presence of a dust layer from 7 to 10 cm thick is suggested from astronomical observations and theoretical studies. — V. S. N.

- 186-92. Öpik, Ernst J. Tidal deformations and the origin of the moon: *Astron. Jour.*, v. 66, no. 2, p. 60-67, 1961.

A provisional survey of the ellipticities of lunar craters indicates that there are small preferential components of ellipticity which are interpreted as possible aftereffects of past tidal deformations. The smallness of the preferential effects is in itself significant and suggests that the craters were formed when the moon was 30,000-50,000 km distant from the earth.

Possible modes of origin of the moon are discussed in the light of theoretical rates of accretion based on probabilities of interplanetary collisions. If the pre-mare craters mark the end of a continuous process of accretion, the observed small systematic deformations mean that the moon could only have accreted from a cloud of fragments circling the earth in direct orbits at a distance of at least 5-8 earth radii.

If the preferential ellipticities are due to other causes or to chance, it is possible to accept the alternative that the moon accreted from interplanetary material orbiting the sun. Accretion must have run simultaneously with tidal evolution following initial tidal capture, the pre-mare craters having formed at a distance of more than 200,000 km from the earth as the final stage of this accretion. — D. B. V.

- 186-93. Asimov, Isaac. *The double planet*: New York, Abelard-Schuman Ltd., 158 p., 1960.

A popular account is given of how man has probed the nature of the earth and the moon and their relationship to each other from ancient times to the present. The following chapters are included: a sphere, not quite a sphere, the layers beneath, outside the crust, outside the air, the nearness of "nearest," we are pulled, we pull back, and airlessness. In appendixes 1 and 2 are given some specific facts about the physical measurements of the earth and moon. Appendix 3 is a table of important dates in the history of scientific investigation of the earth and moon. — V. S. N.

- 186-94. Hunter, W., and Parkin, D. W. Cosmic dust in Tertiary rock and the lunar surface: *Geochim. et Cosmochim. Acta*, v. 24, no. 1/2, p. 32-39, 1961.

The remains of cosmic spherules, consisting of the outer oxide coating, have been found in a Tertiary formation on Barbados. If it is assumed that cosmic dust has been falling at the same rate throughout geologic time as at present, than a thick uniform blanket should cover the moon's level surfaces and obscure all fine detail. Such monotony is not the case in some regions, however. It is proposed that meteorites have accompanied the dust and that their impact has continually blasted out fresh lunar rock; the powdered rock thus produced smothers the cosmic dust and the composition in any locality is much the same as that of the underlying rock. — D. B. V.

- 186-95. Öpik, E[rnst] J. The lunar surface as an impact counter: Royal Astron. Soc. Monthly Notices, v. 120, no. 5, p. 404-411, 1960.

The dust cover of the moon sticks to mountain slopes and cannot possess any degree of fluidity. Probably only a limited migration of dust into valleys takes place, caused by meteor bombardment. The material of micrometeorites is expected to form a layer of the order of 40 g per cm², accumulating over the maria and protecting them from further erosion by small meteors. Large meteors are not stopped by dust and produce craters; at a velocity of 20 km/s the ratio of crater to projectile diameter is about 20.

The surfaces of the lunar maria can be regarded as a counter which over the ages has registered the impacts of stray bodies and from which conclusions can be drawn as to the present distribution of diameters and number density of these bodies. The frequency distribution of 812 crater diameters in the western part of the Mare Imbrium (measured over an area of 465,000 km²) suggests that since the formation of the mare the population of interplanetary space has not changed appreciably. — D. B. V.

- 186-96. Diggelen, J. Van. Photometric properties of lunar crater floors: Observatoire d'Utrecht Recherches Astron., v. 14, no. 2, 114 p., 1960[?].

The composition of the lunar surface is investigated by means of measurements of its radiance under various conditions of illumination, especially from the lunation curves. In chapters 2-5 the results of the reduction of a number of photographic plates of the moon are discussed. The radiance of the floor of 36 craters was measured at 5 lunar phases by photographic photometry. The results are compared with each other and with results of similar work from other sources. For each crater the radiance is tabulated as a function of the phase of lunation; good agreement is found between the lunation curves of different authors. In chapters 6-9 theoretical explanations for the form of the lunation curve of lunar objects and laboratory apparatus for observation of radiance of materials and models are discussed. The last chapter summarizes all available evidence about the lunar surface obtained by different methods. All observations indicate the existence of a very porous surface layer, very probably due to the continual impact of numerous micrometeorites that reach the surface at their full cosmic velocity of 40 km/s. Most probably this layer is not dust but a solid melting crust formed by the high temperature at the moment of impact and with holes of all sizes, deeper than their diameters. Model studies show that a simplified geometrical description should not be adhered to strictly; it may be necessary to assume that the solid melting crust is covered with a thin coat of ashes. — V. S. N.

- 186-97. Brockamp, B[ernhard]. Zur hypsographische Kurve des Mondes [On the hypsographic curve of the moon]: Zeitschr. Geophysik, v. 26, no. 5, p. 271-272, 1960.

If the moon has had an evolution similar to that of the earth, and particularly if its crust has cooled over a long period, continental and oceanic blocks could have become differentiated and isostatically compensated; in that case, the hypsometric curve of the moon (on whose surface light and dark areas that probably correspond to different rock materials can be distinguished) would show two maximums like that of the earth. If, however, the moon's crust consists of more or less uniform primary matter, or if extensive differentiation and (or) isostatic compensation have not taken place because of too-rapid cooling, then a single peak would be likely. The investigations of Brockhaus and Jokschi (see Geophys. Abs. 184-119) lead to an asymmetrical one-peak distribution; but as no reliable maps of moon elevations are yet available, and only old and inaccurate observational data can be referred to, no far-reaching conclusions should be drawn as yet. — D. B. V.

- 186-98. Yakovkin, A. A. Dvizheniye, vrashcheniye i figura Luny [Movement, rotation, and figure of the moon], in *Lunar [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 7-55, 1960.

The assumption that the moon is a solid body without a liquid or plastic core is supported by numerous observations pertaining to the motions of the moon. It is also accepted that its radius is 1,738 km, its density is 3.33 g per cm³, and its mass is 81.53 times smaller than that of the earth. The moon has an ellipsoidal figure with deviations from a sphere (Hopmann 1952) as follows: large axis, +8.8 km; intermediate axis, +1.1 km; and small axis, -4.7 km. Other recent investigators have shown the absence of symmetry of the figure of the moon with respect to its equatorial plane.

Detailed analyses and observations have shown considerable deviation, designated as physical librations, from Cassini's laws of rotation (1693) due to the nonspherical distributions of density inside the moon and earth. Additional deviations are designated as: optical libration in latitude, optical libration in longitude, topocentric libration, and geocentric libration. Other contributions to rotational theory are mentioned.

The mass of the moon can be determined by the influence of the moon on the rotation or on the orbital revolution of the earth. The first method is expressed in precession and nutation, and the second by inequalities of the earth's latitudes. Detailed theoretical treatments are given to problems of optical librations of the moon, determination of details of the lunar surface, corrections due to the relief of lunar edges, physical librations of the moon, and the figure of the moon. Suggestions are offered on the use of lunar observations for checking geodesy; also on the use of the moon for space navigation. — V. G. G.

- 186-99. Khabibullin, Sh. T. Lunnaya kartografiya i selenograficheskiye koordinaty [Lunar cartography and selenographic coordinates], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 57-75, 1960.

Selenographic coordinates, cartographic nets suitable for mapping the moon, and physical coordinates of the moon are explained in detail by sketches and formulas. Methods for determination of selenographic coordinates are developed analytically.

Reliable methods for making detailed and accurate maps and photographic atlases of the moon have been developed through the efforts of Galileo Galilei (1610), Van Langren (1645), Jan Geveli (1647?), Cassini (1692), Mayer (1775), Schroter (1800?), Lopman (1825?), Medler and Beer (1837), Schmidt (1878), Pikerling (1903), Saunders (1911), Huudaker (1995), and Wilkins (1946).

A method by which lunar explorers can determine their position on the moon is suggested and expressed in an analytical form. Numerous figures are given. — V. G. G.

- 186-100. Markov, A. V. Opisanie lunnoy poverkhnosti [Description of the lunar surface]; in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 77-101, 1960.

The most prominent feature of the lunar surface is the presence of annular forms with diameters ranging from 1.5 to 250 km. In general, the lunar forms can be subdivided into the following classes: rows of cirques; cirque (or crater) seas; radial cirques and craters; parasitic craters; rows of craters; and cirques and phantom craters.

A very detailed description is given of the lunar forms with respect to their dimensions, shape, color, as well as physical properties such as albedo. Changes in appearance of the lunar surface are discussed briefly.

A hypothetical map of the unseen hemisphere of the moon, a map of lunar highs and lows, and numerous photographs of the moon's surface are given. A complete table gives the names of prominent surface features and their coordinates. — V. G. G.

- 186-101. Sytinskaya, N. N. Problema atmosfery Lunny [Problem of the atmosphere of the moon], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 103-124, 1960.

The existence of a lunar atmosphere can be verified by reflection and refraction phenomena. The atmosphere of a planet is in a stable state if, according to Jeans, $v_k < 1/5 v_p$ where v_k is the kinetic velocity of a gas particle, and v_p is the parabolic escape velocity of a gas particle. The application of this formula to the physical conditions existing, or assumed to exist, on the surface of the moon indicates the absence of relatively light gases in its atmosphere; however, the explosion of meteorites striking the surface of the moon, volcanic activity, and radioactive disintegration may be sources of a small amount of gas. The most recent radioastronomical observations indicate the presence of an atmosphere on the moon, and the recent investigations by Edwards and Borst (1958) suggest that the atmosphere of the moon may contain small amounts of xenon and krypton. Refraction phenomena, however, lead to the conclusion that there is no atmosphere on the moon. Spectrographic investigations indicate the absence of an atmosphere or, if present, of magnitudes expressed in 10^{-9} atm. — V. G. G.

- 186-102. Barabashev, N. P. Fizicheskiye svoystva lunnoy poverkhnosti. 1: Al'bedo i tsvet lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 1: Albedo and the color of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 125-156, 1960.

Evaluation of the albedo, brightness, and color of the lunar rocks is significant for determination of the rock types present. These optical characteristics are usually determined by photographic, colorimetric, and spectrophotometric methods. Numerous investigations beginning with Pickering (1882) in the United States to Sharonov (1956) in U. S. S. R. have given their attention to such studies. By using the identical methods for determination of these parameters for terrestrial rocks and by comparing them with those obtained from the lunar investigations, the following rock types are indicated on the lunar surface: volcanic ash, basalt, red quartz porphyry, iron quartzite, and tuff. The lunar surface has considerable variations in color and

brightness; this indicates great variation in rock composition. Numerous tables, one colored photograph of the moon, and a list of 33 references are given. — V. G. G.

- 186-103. Markov, A. V. Fizicheskiye svoystva lunnoy poverkhnosti. 2: Polarizatsionnyye svoystva lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 2: Polarization properties of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 156-174, 1960.

After Arago's discovery (1811) that lunar light has certain polarization properties, Secki (1859) established that this polarization is due to the reflection of light from the solid lunar surface. Petrushevskiy (1873) was the first to give the analytical basis for application of polarization to determination of rock composition of the lunar surface. Lyot and his students in France (1929) made a detailed study of the polarization phenomenon that takes place on the earth and moon surfaces and arrived at the following conclusions: There is no chalk or clay on the moon; granites, porphyries, basalts, and quartz sands of the earth exhibit smaller negative polarization than the average polarization computed for the moon as a whole; natural (nonpulverized) lavas of Vesuvius exhibit larger albedos and maximum polarization magnitudes than those of the moon; and volcanic ash of Vesuvius of high albedo (~ 0.17) gives a maximum positive polarization somewhat similar to that of the lunar continents. — V. G. G.

- 186-104. Zel'tser, M. S. Fizicheskiye svoystva lunnoy poverkhnosti. 3: Temperatura lunnoy poverkhnosti [Physical properties of the lunar surface. Pt. 3: Temperature of the lunar surface], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 174-202, 1960.

Radiation energy (E) received by the moon from the sun can be expressed by the following formula: $E - E_r - E_c - E_e = \eta \sigma T^4$; where E_r is the reflected radiation energy; E_c is the thermal conduction radiation energy; E_e is the radion energy of the moon; η is the coefficient of the efficiency of radiation at a given point on the lunar surface; σ is the Stefan-Boltzmann constant; and T is the temperature in K° of the surface of the moon. Apparatus for measuring lunar temperature usually consists of a spherical mirror, a filter system, and thermocouples.

Pettit and Mickelson (1930, 1934) were the first to make observations of temperatures and reflection properties (long waves) of the lunar surface as a function of the phase and height of the sun over the horizon. Van Vleck (1947), Sinton (1955, 1956), Yaroslavskiy (1957), Markov and Chistyakov (1960), Weselnik (1948), Jaeger (1953), and others have made considerable contributions to the theory and accumulation of data.

At the onset of night the temperature of the lunar surface falls to $170^\circ K$, and after 14 days, in accordance with the theoretical considerations, should drop to $100^\circ K$. Below the surface the rate of cooling should be smaller and become negligible at depths ranging from 10 to 12 cm. It is estimated that cooling is responsible for the emission of energy equal to 109.8 calories per cm^2 in 14 days. — V. G. G.

- 186-105. Kaydanovskiy, N. L. Issledovaniye Luny pri pomoshchi radiometodov [Lunar investigations with the use of radiomethods], in Luna [Moon]: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 203-240, 1960.

The intensity of radar signals reflected from the moon and observed on the earth depends on many factors such as intensity of the initial emission, sensitivity of the receiver, the area of the antenna, the effective areal scattering of the target, the noise powers of the receiver, the cosmic radiation, and the surface properties of the moon. Analytical formulas derived by many investigators are given here, and the data obtained are discussed.

One of the main purposes for using radar was to determine the distance to the moon with an error of less than 1 km. Detailed radar observations should also lead to correct evaluation of some of the lunar surface properties. Both the radar and radioastronomical methods in reality measure the heat waves emitted by the upper layer of the lunar surface. — V. G. G.

- 186-106. Khabakov, A. V. Kharakternyye osobennosti rel'yeva Luny. Osnovnyye problemy genezisa i posledovatel'nosti razvitiya lunnykh formatsiy [Characteristic features of the relief of the moon. Basic problems in the genesis and gradual development of lunar forms], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 241-297, 1960.

The moon is characterized by the following features: a belt of broad depressions, traces of asymmetry in the lunar figure, and the presence of a triaxial configuration due to the gravitational attraction between the earth and moon. Lunar forms can be subdivided into the following classes according to size: planetary, megarelief, superrelief, macrorelief, mesorelief, microrelief, and infrarelief. Lunar forms can be subdivided according to age beginning with the oldest forms as follows: Ancient, pre-Altaï, Altaï, Ptolemaic, Oceanic, Copernican, and Recent.

The attempt is made to correlate the various lunar forms with time and mode of origin. Endogenic tectonomagmatic processes are accepted as responsible for 10 to 20 percent of the circular lunar mountains of Recent age. The Copernican period of lunar history was 2.5×10^6 - 5.0×10^6 yr in duration. — V. G. G.

- 186-107. Stanyukovich, K. P., and Bronshten, V. A. Rol' vneshnikh kosmicheskikh faktorov v evolyutsii Luny [Role of external cosmic factors in the evolution of the moon], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 299-329, 1960.

Although the exogenic theory of the origin of lunar craters was proposed in 1846, the first basic contributions were made by Wegener in 1913. In spite of Wegener's contributions, numerous investigators such as Khabakov (1949), Spurr (1944), Bülow (1957), and others have supported the endogenic theory as responsible for the origin of the majority of the lunar surface forms. During the last decade Baldwin (1949), Urey (1956), Stanyukovich (1947, 1950, 1955), and others have contributed greatly to the support of the exogenic theory. The followers of the endogenic origin of the lunar forms, such as Khabakov, recognize the meteoric origin of the lunar "micro" craters. Numerous curves, photographs, tables, and a list of 22 references are given. — V. G. G.

- 186-108. Sharonov, V. V. Priroda lunnoy poverkhnosti [Nature of the lunar surface], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 331-364, 1960.

Some of the physical properties of the lunar surface as determined by reflected light and radar waves are: The lunar surface is covered everywhere

with black material; the differences in color on the moon are very small; the maximum intensities of reflected solar light are toward the sun independently of the angle of incidence of the solar radiation; the light reflected from the lunar surface is partially polarized; the lunar atmosphere, if existent, is physically insignificant; thermoelectrical measurements of changes in temperature during lunar eclipses indicate a very low conductivity of the uppermost layer of the lunar surface; and the lunar surface is always under the action of cosmic radiation.

Detailed descriptions and evaluations are given of the following hypotheses: fresh surfaces of lunar magmatic rocks; change in mineral coloration under the influence of radiation; lunar zone of weathering and sedimentary rocks; lunar layer of meteoric material; and the meteor-slag hypothesis. Several tables, diagrams, and a list of 74 references are given. — V. G. G.

- 186-109. Markov, A. V. Zaklyucheniye [Conclusion], in *Luna [Moon]*: Moskva, Gosudarstvennoye Izdatel'stvo Fiziko-Matematicheskoy Literatury, p. 365-377, 1960.

The space vehicles sent to the moon on January 2, 1959, September 12, 1959, and October 4, 1959 indicate the almost complete absence of a lunar magnetic field and the presence of sparse accumulations of cosmic particles at a distance of 10,000 km from the moon.

A careful study of the material collected in this book as a whole indicates: The Gold hypothesis pertaining to the presence of lunar dust layers of depths up to several tens of meters is absolutely wrong; it is probable that basic rocks are exposed in the lunar mountains; large variations in lunar temperature and the presence of certain lunar activities should generate fissures of large and small dimensions; the existence of negative polarization and poor conductivities might indicate the presence of fine-grained surface rocks with a thickness not less than 5 cm; assuming the meteor-slag hypothesis is correct, the uppermost crust of the moon must be accepted as composed of material that is harder than powder; intensive application of powerful telescopes, radar, and thermoelectric methods for lunar investigations should give valuable information; and the use of space platforms should increase the usefulness of the methods based at present on the earth. — V. G. G.

- 186-110. Lipskiy, Yu. N. Charting the hidden side of the moon: *Sky and Telescope*, v. 21, no. 3, p. 133-139, 1961; translated from *Astron. Zhur.*, v. 37, p. 1043-1052, 1960.

The techniques used in photographing the hidden side of the moon are described, and the methods of evaluating these photographs are discussed. A total of 499 objects were identified, about 100 of which are observable from the earth. The outlines and coordinates of many of the latter features were obtained more precisely than those given on existing maps. The two hemispheres are unlike in that there are no extensive depressions on the hidden side such as the Oceanus Procellarum and Mare Imbrium. Features on the far side are otherwise not different in nature from those on the visible side. Regions rich in bright craters occupy a large part of the hitherto unobserved side. There are also ray systems and mountain ranges. — J. W. C.

- 186-111. Academy of Sciences of the U.S.S.R. First photographs of the reverse side of the moon: Moscow, Foreign Languages Publishing House, 35 p., 1960.

The results of a preliminary study of photographs of the reverse side of the moon are discussed and the instrumentation described. The report is in four

chapters as follows: the design of the automatic interplanetary station, the interplanetary station in flight, taking and transmitting the photographs, and the hidden side of the moon. On the basis of this study it is seen that the reverse side of the moon is dominated by mountainous areas with few seas. The crater seas in the southern and equatorial regions are very conspicuous. These topographic features are identified on one of the photographs and in a sketch. — V. S. N.

- 186-112. Barabashev, N. P. Novyy etap izucheniya Luny [The new stage in the study of the moon]: Akad. Nauk SSSR Vestnik, no. 10, p. 32-36, 1960.

Knowledge of the moon secured by optical, radioastronomical, and cosmological means is summarized. — A. J. S.

- 186-113. Mikhaylov, A. A. Pervaya karta obratnoy storony Luny [The first map of the back side of the moon]: Akad. Nauk SSSR Vestnik, no. 1, p. 39-42, 1961.

A description of the process for obtaining the data and producing the map of the back side of the moon is presented. The surface features of the back side of the moon and the difference in surface structure of the back and the front sides are discussed. A map is included. — A. J. S.

- 186-114. Lipskiy, Yu. N. Izuchaya fotografii... [Studying the photographs...]: Nauka i Zhizn', no. 3, p. 27-31, 1961.

Studies and interpretations of the photographs of the distal side of the moon taken from the U.S.S.R. interplanetary rocket on October 7, 1959 are reported. The conditions under which the photographs were taken are described, the instrumentation of the rocket is discussed, and the new method of treatment of negatives—the photometric profiles method—is explained. The types of lunar formations are discussed. — A. J. S.

- 186-115. Linder, I. Simposium "Luna" [Symposium, "the moon"]: Nauka i Zhizn', no. 3, p. 17-21, 1961.

This is a popular report on the "International symposium on the moon," held in Leningrad and Pulkovo in December 1960. Various aspects of selenology discussed at the symposium are presented briefly. — A. J. S.

- 186-116. Öpik, E[rnst] J. The aeolosphere and atmosphere of Venus: Jour. Geophys. Research, v. 66, no. 9, p. 2807-2819, 1961.

A self-consistent model of the Venus atmosphere that satisfies the multitude of existing observational data is proposed. The surface temperature of 570°K requires blanketing by dust particles. The term "aeolosphere" is proposed for the region between the surface and the clouds of Venus, where wind is responsible for grinding and raising the dust as well as for the heating. The dust may consist mainly of calcium and magnesium carbonates. — D. B. V.

EARTH CURRENTS

- 186-117. Vladimirov, N. P., and Kolmakov, M. V. O razreshayushchey sposobnosti magnito-telluricheskogo metoda [On the resolving power of the magnetotelluric method]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1598-1600, 1960.

The magnetotelluric method using variations of the natural electromagnetic field of the earth is studied with regard to its application to investigations of a geoelectric profile made up of horizontal layers of thickness h_1 , h_2 , and $h_3=\infty$ and having resistivities ρ_1 , $\rho_2 > \rho_1$, and $\rho_3 = \infty$. For such a section the magnetotelluric method has a better resolving power than the d-c resistivity method, provided the layers are thick. — A. J. S.

- 186-118. Shaub, Yu. B. Ob interpretatsii rezul'tatov izmereniy ugla naklona ploskosti polarizatsii yestestvennogo peremennogo magnitnogo polya [Interpretation of results of measurements of the angle of inclination of the polarization plane of a natural alternating magnetic field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1771-1777, 1960.

As the natural magnetic field of the earth has an approximately circular polarization in the range of sonic frequencies with the plane of polarization parallel to the surface of the earth (see Geophys. Abs. 179-151), a conducting underground body can change the inclination of the polarization plane, and a geoelectric profile of the crust can be established. Variations in the inclination angle of the polarization plane are analyzed mathematically, and formulas are derived for spherical and cylindrical conducting bodies to determine the depth of the body from the surface, the radius of the body, its specific electric conductivity, and other auxiliary parameters. — A. J. S.

- 186-119. Vladimirov, N. P., and Nikiforova, N. N. K metodike interpretatsii krivyykh magnetotelluricheskogo zondirovaniya [On the method of interpretation of curves of magnetotelluric sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 111-113, 1961.

Magnetotelluric profiling uses field fluctuations less than 0.1 cycles per second in studying the profile of the basement where it is buried at depths of several kilometers. Magnetotelluric sounding utilizes frequencies greater than 0.1 cycles per second both for study of the basement and for discrimination of the sediments overlying the basement. Procedures for interpreting experimental curves are outlined. The experimental curves are plotted on the same scale as theoretical curves. This permits the same interpretive procedure as that used with the d-c resistivity method. An example is presented from the Dnieper-Donets depression; the results are in full agreement with geological and geophysical ideas on the structure of this region. — J. W. C.

- 186-120. Lipskaya, N. V., Deniskin, N. A., and Yegorov, Yu. M. Rezul'taty elektromagnitnogo zondirovaniya v tsentral'noy oblasti Dneprovsko-Donetskoy vpadiny [The results of electromagnetic sounding in the central region of the Dnieper-Donets depression]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 407-411, 1961.

Investigations of microvariations of the natural magnetic field of the earth in the frequency range 0.005-1 cycles per second in the Dnieper-Donets depression are reported. The purpose of the investigations was to examine whether or not the earth's electromagnetic impedance could be used for constructing geoelectric profiles of the crust. The geological section here consists of 5 sedimentary formations 900-1,200 m thick with apparent resistivities $\rho_1 < \rho_2 > \rho_3 < \rho_4 > \rho_5$. The observations were made with a magnetostatic microvariometer, and the horizontal components of the field E_x , E_y , H_x , and H_y were recorded. The curves of apparent resistivity of the profile calculated from the data of the electromagnetic sounding were found to agree satisfac-

torily with a theoretically constructed curve but showed considerable scattering of the impedance values. This is explained by variations in the characteristics and location of the sources of the field. — A. J. S.

- 186-121. Kolmakov, M. V., and Vladimirov, N. P. K voprosu ob ekvivalentnostikrivykh magnitotelluricheskogo zondirovaniya [On the problem of equivalence of magnetotelluric sounding curves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 544-552, 1961.

Defining the MTZ (magnetotelluric sounding) curves as equivalent where there is a practical coincidence of apparent resistivities for identical values of T-period variations of the natural electromagnetic field of the earth, the equivalence is analyzed on the basis of the equation of the equivalence and the curves for an electrically homogeneous half-space that has a high resistivity layer. The data for MTZ are compared with the equivalence principle in the method of vertical electric soundings. A suggestion is made to complement the MTZ method with the method of vertical electric sounding and other methods of electric prospecting in order to compensate for and remove the ambiguities of the results inherent in either method separately. — A. J. S.

- 186-122. Rösler, R. Erdstromregistrierung in Nordschweden [Earth current records in northern Sweden]: Arkiv Geofysik, v. 3, no. 4, p. 331-336, 1961.

Telluric current surveys in the Skellefte district of northern Sweden revealed that when the dimensions of an orebody are large, a phase displacement appears at low frequencies, generating an alternating current that constitutes a technical difficulty. This problem has been investigated by new measurements in the Kankberg and Näsleden areas (see Geophys. Abs. 178-174), using a method that differs from the usual methods in that it measures the potential drop over a stretch containing an orebody and another over homogeneous ground on the same profile.

Results are illustrated by reproductions of segments of the records obtained on certain nights. Quasi-periodic variations were clearly recorded on the nights of October 9, 10, and 11, 1955. These curves show a definite diminution of amplitude over the orebody, and in the records of October 10 and 11 the curves obtained over the orebody and those over the control stretch are opposite in phase. Further investigations will be necessary to explain these phenomena; the magnetograms of the Kiruna and Lovö stations for the days in question show no apparent special features. — D. B. V.

Barsukov, O. M. On the problem of three "velocities" of corpuscular streams. See Geophys. Abs. 186-487.

EARTHQUAKES AND EARTHQUAKE WAVES

- 186-123. Lomnitz, C[inna]. On thermodynamics of planets: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 157-161, 1961.

A thermodynamic theory of planets is outlined. General results pertaining to irreversible processes are applied to the case of a steady-state system with constant temperature distribution. An "excited state" is defined by pressure perturbation introduced by an earthquake at the surface of the planet. The resulting transient flows toward the perturbed region are analyzed, and it is shown that the energy transient is logarithmic in time. An explanation of after-shocks as caused by local stress adjustments due to the influx of energy is a natural consequence of this theory.

The seismic process may also be viewed as an intermittent regulating device; in this case temperature can no longer be assumed to be constant. A condition of realizability of the earthquake problem is defined. If heat production of a planet falls below a certain amount, all seismic activity will cease. Conversely, in a series of planets of different sizes, all having similar heat productions and heat flow rates, there will be a critical radius below which no earthquakes can occur. The surface of such planets will be smooth and free of the scars of orogeny, and they will be devoid of atmosphere, oceans, and traces of past or present volcanic activity. — D. B. V.

- 186-124. Rothé, J[ean]-P[ierre]. Tableau de la séismicité du globe pendant l'année 1957 (Chronique séismologique) [Catalogue of the seismicity of the globe during the year 1957 (seismological chronicle)]; Rev. Étude Calamités, no. 36, p. 3-37, 1959.

In 1957 the International Bureau of Seismology studied 3,044 earthquakes, for which 2,201 epicenters were determined in contrast to the 2,727 epicenters for the two years 1955-56. The increase in the number of epicentral determinations is a direct result of the more active collaboration between stations and the International Bureau at Strasbourg brought about by the International Geophysical Year. The earthquakes that resulted in loss of human life are given in a table; the greatest catastrophes were located in Turkey, Mongolia, and Iran. As in previous chronicles, the major earthquakes of the year are listed in tables and grouped according to large orogenic regions of the world. Brief descriptions are given for the 333 earthquakes listed. — V. S. N.

- 186-125. MacCarthy, Gerald R. North Carolina earthquakes, 1958 and 1959, with additions and corrections to previous lists: Elisha Mitchell Sci. Soc. Jour., v. 77, no. 1, p. 62-64, 1961.

Only one earthquake occurred (March 5) within the boundaries of North Carolina during 1958; its epicenter was just off the coast near Wilmington. No earthquakes occurred in the state during 1959. Eleven nineteenth-century shocks are added to the state list and one (April 9, 1918) deleted (see Geophys. Abs. 171-65). — V. S. N.

- 186-126. Fischer, William A. Yellowstone's living geology—Highlights of Yellowstone geology with an interpretation of the 1959 earthquakes and their effects in Yellowstone National Park: Yellowstone Nature Notes, v. 33, 1959-60 Special Issue, 62 p., 1960.

The geologic history of the Yellowstone Park area is reviewed, and the changes produced by the earthquake of August 17, 1959, in the scenery and in the thermal activity in the park are discussed. The text includes the following 13 chapters: the causes of earthquakes, the mechanics of earthquakes, a glimpse into the past, early mountain building, Yellowstone's fiery past, the modern park unfolds, Yellowstone's structural framework, earthquake history of immediate area, earthquake water table effects around the world, a tour of the earthquake area, changing geysers and hot springs, summary, and a prediction for the future. The booklet is well illustrated with maps and pictures and has a glossary of technical terms and a bibliography. — V. S. N.

- 186-127. Nile, Stephen W. The Hebgen Lake earthquakes: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 24-30, 1960; also in De Re Metallica, v. 26, no. 3, p. 2-12, 1961.

The epicenters of the strong Hebgen Lake, Mont., earthquakes of August 17-19, 1959, and of the aftershocks were located in an area 70 miles from east

to west and 35 miles from north to south. The earthquakes of 1959-60 in this region of the Rocky Mountains occurred in the same parts of eastern Idaho, southwestern Montana, and extreme western Wyoming as have most of the strong earthquakes since 1869. Tables are presented to show a comparison of intensity, magnitude, and affected area for four strong Montana earthquakes, maximum accelerations recorded for several Montana earthquakes, and epicenter determinations from August 1959 to June 1960. An isoseismal map for the 1959 earthquake is shown in comparison with that for the earthquake of November 23, 1947. The focal depth of the initial earthquake (time of origin 06:37:15.0 G. c. t., August 18, 1959, location, lat 44°50' N., long 111°05' W.) is estimated at 10-12 km. Precise leveling by the U. S. Coast and Geodetic Survey has revealed that a section of Highway 287 four miles southeast of Hebgen Dam settled 18.86 feet. This is thought to be the greatest vertical displacement from an earthquake ever detected in the western United States by precise leveling. — V. S. N.

- 186-128. Witkind, Irving J. The Hebgen Lake, Montana, earthquake of August 17, 1959: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 31-44, 1960.

Repeated dropping and tilting of fault blocks has occurred in the Hebgen Lake area, Montana, since late Tertiary time. The earthquake of August 17, 1959, occurred when two fault blocks east of the Madison Range and one west of the Range dropped and tilted, synchronously reactivating the marginal normal faults. Prominent fault scarps appear to be coincident with or closely parallel to the reactivated faults; the major scarps, north of Hebgen Lake and facing southward, have a maximum displacement of about 20 feet near their midpoints. The subsidence and northward tilting of the fault block containing Hebgen Lake displaced the lake northward and produced a seiche that lasted for 11½ hr. Damage to Hebgen Dam was extensive and parts of former Highway 287 slid into Hebgen Lake; in places along the north shore, sand spouts were formed. A large earthflow near Kirkwood Canyon began moving about a week after the main shock, toppling trees and draining a lake. — V. S. N.

- 186-129. Hadley, Jarvis B. The Madison landslide: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 45-48, 1960.

One of the effects of the Hebgen Lake earthquake of August 17, 1959, was to trigger a massive rockslide in the lower part of the Madison River canyon six miles below Hebgen Lake. Thirty-seven million cubic yards of broken rock slid from an area half a mile long on the south side of the canyon and covered a mile of the canyon floor with debris to a maximum depth of 220 feet. Its momentum was sufficient to carry the leading edge of the slide 300 vertical feet up the opposite wall of the canyon. The determining conditions were structural and physiographic centering around a dolomite wedge and its effect on the stability of the fractured and weathered rocks on the slope above. The slide dammed the Madison River and created a lake which had attained a depth of 190 feet just above the slide 3½ weeks after the earthquake. — V. S. N.

- 186-130. Woodward, F. W. Red Canyon fault, Hebgen Lake, Montana, earthquake August 17, 1959: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 49-55, 1960.

The Red Canyon fault, which extends northwest for 14 miles from near the west boundary of Yellowstone Park approximately to the Hebgen Dam on Madison River, is a normal fault on the west side of a zone of high angle reverse

faults bordering the eastern flank of a large north tilted block; the zone dates from the Laramide orogeny. The Red Canyon fault zone is described and interesting phenomena resulting from reactivation of the fault by the Hebgen Lake earthquake of August 17, 1959, are discussed. — V. S. N.

- 186-131. McAleer, Joseph F. A rotational fault block in the Madison River earthquake area: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 56-60, 1960.

One of the smaller fault scarps resulting from the Hebgen Lake earthquake is described. The feature has upper and lower limbs which when considered as a unit form a classical rotational fault block. A small movement of this nature usually is classified as slump, but the fact that bedrock was broken in the face of the upper scarp definitely classifies it as faulting. — V. S. N.

- 186-132. Marler, George D. The 1959 Hebgen Lake earthquake alters Yellowstone's hot springs: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 61-66, 1960.

The 1959 Hebgen Lake, Mont., earthquake caused a noticeable increase in thermal energy in the hot-spring areas of Yellowstone Park. Springs along the Firehole River drainage were particularly affected, and, to a lesser degree, those on the Gibbon River drainage. The eastern sections of the park were little affected. In addition to a general increase in activity of geysers with predictable patterns of play, 160 springs with no record of previous geyser functioning erupted immediately following the initial earthquake. The waters in many springs changed from clear to muddy, and there were indications of a considerable lowering of the water table. On the morning after the initial shock the water in 363 springs had ebbed from a few inches to several feet. By the end of 1959 only nine springs showed no changes attributable to the earthquake. The causes of the changes in thermal activity are discussed, and some of the new geyser activity is described. The role of earthquakes in the origin of Old Faithful geyser is also discussed. — V. S. N.

- 186-133. Ball, R. M. The Madison earthquake and its effects: Billings Geol. Soc. 11th Ann. Field Conf. for 1960, West Yellowstone-Earthquake Area, p. 71-77, 1960.

The major effects on both man-made and natural structures of the earthquake of August 17, 1959, at lat 44°50' N., long 111°05' W., are discussed. The major landslide below Hebgen Dam and the resulting natural lake, changes in level of Hebgen Lake, Mont., damage to the dam and nearby roads, major faulting, "tidal" waves on Hebgen Lake, and the emergency engineering work carried out to prevent further disaster are described. — V. S. N.

- 186-134. Sanford, A. R., and Holmes, C. R. Note on the July 1960 earthquakes in central New Mexico: Seismol. Soc. America Bull., v. 51, no. 2, p. 311-314, 1961.

Earthquakes were felt in the Rio Grande valley in central New Mexico on July 22, 23, and 24, 1960. The strongest had a maximum intensity of 6 at La Joya. An average epicenter at lat 34°21.7' N. and long 107°2.6' W. was obtained on the basis of 28 smaller shocks recorded at Socorro. In addition to the direct P- and S-phases, the seismographs showed sharp phases approximately 0.35, 1.95, 5.50, and 7.80 sec after the direct P-phase. — D. B. V.

- 186-135. Cameron, J. B. Earthquakes in the northern California coastal region (pt. 1): *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 203-221, 1961.

P_n and S_n velocities are determined for earthquakes originating in the northern California coastal region. The existence of station delays at the Shasta, Mineral, and Reno seismic stations is proved for these earthquakes. A method of locating epicenters in this area is described, and epicenters are found for all large earthquakes that have occurred since the installation of the Corvallis station in 1950. The crustal structure inferred from the data from these earthquakes is as follows: the sedimentary layer, $V_{P_F}=5.1$ kmps, extends to a depth of 3 km; the granitic layer, $V_P=5.95$ kmps, extends to 24 km (Conrad discontinuity); the basaltic layer, $V_{P^*}=6.93$ kmps, extends to 29 km (the M-discontinuity); and the underlying mantle has a velocity of $V_{P_n}=7.98$ kmps. — D. B. V.

- 186-136. Hirono, Takuzo. The Chilean earthquake of 1960: *Jour. Geography* [Tokyo], v. 70, no. 3, p. 122-133, 1961.

The Chilean earthquake on May 22, 1960, is discussed and its effects described. The magnitude was determined by the Matsushiro Observatory as 8.75. The large tsunami generated by the earthquake created great damage from Chile to Japan, the first phase reaching the coast of Japan 22 hr after the earthquake. The largest phase attained a height of 5 m at Hachinohe and destroyed villages from Kiritappu in Hokkaido to Ago Bay in the Kinki district. — V. S. N.

- 186-137. Tillotson, E[rnest]. The Agadir earthquake: *Nature*, v. 190, no. 4771, p. 138-139, 1961.

This is a summary of a report by P. Erimesco that appeared in the *Inst. Pêches Maritimes Bull.* (Morocco), no. 5, 1960. An earthquake of unusually high intensity for the region (9-10) devastated the town of Agadir, Morocco, during the night of February 29, 1960 (origin time 23h40^m12^s G. m. t.). The local estimate of focal depth was 3-7 km and of magnitude, 5.75-6. Calculated according to Karník's formula relating magnitude and intensity, and using values of $I_0=10$ and $h=5$ (I_0 =intensity at epicenter, h =focal depth) the magnitude is 6.48. Reports of sea floor changes (from 900 m to 15 m and from 90 m to 10 m depth) were later proved to be unfounded.

There is evidence of a most unusual phenomenon, namely an area of intense earthquake destruction practically on the shoreline and virtually no effect at sea—neither on the bottom nor as waves—except perhaps the rising of a shoal of zooplankton and a cloud of mud in the sea. This is explained by the local geology. Earthquake waves in the steeply dipping Cretaceous and Tertiary strata are propagated mainly in the solid rock and, by total reflection, literally channeled toward the outcrop of these strata on the coast. In the horizontally overlying unconsolidated and saturated Quaternary and Recent layers the shock wave energy is largely dissipated in the material and only locally can a fraction reach the surface of the sea. — D. B. V.

- 186-138. Panasenko, G. D. Zemletryaseniya na Kol'skom poluostrove 2 i 9.2, 1960 [Earthquakes of February 2 and 9, 1960 in the Kola Peninsula]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 4, p. 567-573, 1961.

Earthquakes occurred in the Kola Peninsula on February 2, 1960 at 12h32^m and on February 9, 1960 at 21h32^m Greenwich time. Their intensities were

5 and 3-4 points, depths of focuses 30 km, and 5 km, energies $E=10^{19}$ - 10^{20} ergs and 10^{14} ergs, and magnitudes $4.0 < M < 4.5$ and $2.5 < M < 3$, respectively. — A. J. S.

- 186-139. Tabulevich, V. N. Makhachkalinskoye zemletryaseniye v marte 1960 [Makhachkala earthquake of March 1960]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1612-1613, 1960.

An earthquake near Makhachkala on the western shore of the Caspian Sea on March 21, 1960 is described. The first shock occurred at 00^h02^m and the second at 00^h07^m Greenwich time. The epicenter was located at lat 42°45' N. and long 47°40' E. (24 km from Makhachkala). The magnitude was 4.5 and the greatest intensity was 6.5. The focal depth was approximately 8 km. — A. J. S.

- 186-140. Gorelikov, S. A. Ochagi zemletryasenyi v Irane [Sources of earthquakes in Iran]: Priroda, no. 12, p. 67-68, 1960.

An account is given of several strong earthquakes that occurred in Iran in the 18th, 19th, and 20th centuries, with reference to the five seismically active zones. — A. J. S.

- 186-141. Matumoto, Tosimatsu. Tesikaga earthquake of Jan. 31, 1959 (in Japanese with English summary): Tokyo Univ. Earthquake Research Inst. Bull., v. 37, no. 3, p. 531-544, 1959.

An earthquake of magnitude 6.2 occurred near Tesikaga on Hokkaido, Japan, at 5^h39^m (G. m. t.) on January 31, 1959. The focus was located at lat 43°26' N., long 144°23' E., 20 km depth. A foreshock of magnitude 5.6 had occurred in the same region at 16^h33^m on January 22. The Ishimoto-Iida formula $nA^{-m}k$ held good over the wide amplitude range of these shocks; at Tesikaga the value of m was 1.91. Aftershocks were observed at Tesikaga and Okusyunbetuby means of electromagnetic seismographs during the period February 14-March 1. The strongest aftershock occurred about 100 min after the main shock and had almost the same magnitude. The epicenters of the aftershocks, determined from the P-S time and an assumed true P-wave velocity, were found to be located only north of the zone of earthquake faults at the eastern foot of Mount Pakeru; the epicenter of the main shock was south of this fault zone. — D. B. V.

- 186-142. Bune, V. I., Gzovskiy, M. V., Zapol'skiy, K. K., Keylis-Borok, V. I., Krestnikov, V. N., Malinovskaya, L. N., Nersesov, I. L., Pavlova, G. I., Rautian, T. G., Reysner, G. I., Riznichenko, Yu. V., and Khalturin, V. I. Metody detal'nogo izucheniya seysmichnosti [Methods of detailed study of seismicity]: Akad. Nauk SSSR Inst. Fiziki Zemli Trudy, no. 9 (176), 327 p., 1960.

This is a monograph devoted to detailed study of seismicity. Seismic apparatus, new methods for large-scale determinations of coordinates of seismic focuses, and methods of determination of detailed structure of the earth's crust are described. Determination of seismic energy, analysis of the relationship between the seismic energy source and the prevalent seismic frequencies, and frequency-selective apparatus are described and discussed. Calculation of the magnitudes and of shifts within sources is treated. Methods of investigation of seismic activity and a comparison of the spatial distribution of seismicity with geologic structure of the region investigated are given. The above discussions are illustrated by seismic data of the Garm and Stalinabad regions. A bibliography of 272 titles is given. — A. J. S.

- 186-143. Solov'yev, S. L. Nekotoryye statisticheskiye raspredeleniya zemletryaseniy i tektonicheskoye stroeniye seysmicheskikh zon [Certain statistical distributions of earthquakes and the tectonic structure of seismic zones]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 25-32, 1961.

The statistical distribution of earthquakes in time and space, such as the relation between frequency of occurrence of strong and weak earthquakes and their distribution in the upper part of the mantle, may depend on geologic structure. An attempt is made to construct graphs of earthquake recurrence in the seismic zones of the U. S. S. R. from data of earthquakes of $M \geq 5$ or more during the period 1911-59. — A. J. S.

- 186-144. Kirillova, I. V., Lyustikh, Ye. N., Rastvorova, V. A., Sorskiy, A. A., and Khain, V. Ye. Analiz geotektonicheskogo razvitiya i seysmichnosti Kavkaza [Analysis of the geotectonic development and seismicity of the Caucasus]: Moscow, Akad. Nauk SSSR Inst. Fiziki Zemli, 340 p., 1960.

This book presents the results of geological-geophysical investigations by the Caucasus Geological-Geophysical Expedition since the middle of 1950. A detailed history of the geology of the Caucasus during the Cenozoic and Mesozoic eras is given, problems of tectonic regionalization are discussed, and gravimetric features are compared with geotectonic data. An historical survey of studies of the seismicity of the Caucasus, description of its regional seismicity, and an analysis of its seismic activity are given. A general analysis of seismic-tectonic data includes geologic criteria of seismic activity and a comparison of the latter with structure. The problems of preparing a new map (scale 1:1,000,000) of seismic regionalization are discussed, and the structure and seismicity of the Caucasus and of adjacent countries are compared. The bibliography contains 654 titles. — A. J. S.

- 186-145. Tskhakaya, A. D. Nekotoryye rezul'taty izucheniya zemletryaseniy Kavkaza [Some results of study of earthquakes in the Caucasus]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1931-1936, 1961

The seismicity of various zones in the Caucasus within the territory of lat 38° - 46° N., and long 38° - 54° E. is described, and the distribution of earthquakes in this region is analyzed according to frequency and magnitude. — A. J. S.

- 186-146. Kirillova, I. V. O poperechnoy differentsiatsii sovremennykh tektonicheskikh dvizheniy v zone yuzhnogo sklona vostochnogo Kavkaza [Transverse differentiation of recent tectonic movements in the zone of the south flank of the eastern Caucasus]: Moskov. Obsch. Ispytateley Prirody Byull. Otdel Geol., v. 36, no. 1, p. 24-39, 1961.

Transverse flexures in the eastern Caucasus are traced by geomorphic means. The seismicity of the region is discussed in connection with explaining these movements, and a seismicity map is presented. — J. W. C.

- 186-147. Bulin, N. K., Bubnova, V. I., and Pronyayeva, Ye. A. O seysmichnosti Turkmenii i Severo-vostochnogo Irana v 1957-1959. [On the seismicity of Turkmenia and northeastern Iran in 1957-1959]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 534-540, 1961.

Instrumental data on 183 earthquakes that occurred in the Turkman S. S. R. and in northeastern Iran during 1957-59 are analyzed and synthesized. By

comparing the seismicity and the subsurface structure it was found that the focuses of earthquakes on the platform are distributed in general along mobile zones, that most of the epicenters are located in areas where the crust is 35-40 km or more thick, and that several platform earthquakes were located in zones of large horizontal gravity gradients. The weak earthquakes in these regions occurred in general during 1957-59 in zones where strong earthquakes have occurred in the past. — A. J. S.

- 186-148. Bune, V. I. Nekotoryye rezul'taty detal'nogo izucheniya seysmicheskogo rezhima stalinabadskogo rayona za 1955-1959 gg [Some results of detailed study of seismicity characteristics of the Stalinabad region for 1955-59]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 369-378, 1961.

The relationship of earthquake sources to the main faults was studied, the parameters of seismic activity rates compared for short-term and long-term observations, and maps of seismic activity compared with maps of isoseists based on microseismic data. — Author's abstract, A. J. S.

- 186-149. Fedotov, S. A., Aver'yanova, V. N., Bagdasarova, A. M., Kuzin, A. P., and Tarakanov, R. Z. Nekotoryye rezul'taty detal'nogo izucheniya seysmichnosti Yuzhnykh Kuril'skikh ostrovov [Certain results of a detail study of seismicity of South Kuril Islands]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 633-642, 1961.

A preliminary report is presented on the results of a geological and geophysical investigation in the region of the Kuriles, Kamchatka, Okhotsk Sea, and the deep Kuril Depression in 1957-59 to explore the transition zone between the continent and the ocean and to determine the seismicity of the southern part of the Kuril-Kamchatka Island Arc. The mean seismic wave velocities in the crust were found to be $\bar{v}_{s-p}=8.4$, $\bar{v}_p=6.1$, and $\bar{v}_s=3.5$ km/s. The mean velocities in the upper zone of the mantle under the islands and under the continental slope of the depression were determined as $\bar{v}_{s-p}=10.6$, $\bar{v}_p=7.8$, and $\bar{v}_s=4.5$ km/s, v_p/v_s diminishes at depths of 50-80 km, and $\bar{v}_p=8$ km/s prevails at the M-discontinuity. This indicates that v_p and v_s decrease with depth in the upper zone of the earth's mantle and leads to the conclusion that the anomalous drop in energy flux from focuses 70-100 km deep, measured at epicentral distances commensurate with depth, is caused by an intense absorption of seismic waves below a depth of 50-60 km. — A. J. S.

- 186-150. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 2. A brief review of seismicity in Wakayama Prefecture based on intensity investigations [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 593-608, 1959.

Very small local earthquakes are often felt in the central part of Wakayama Prefecture that are not recorded at the two seismic stations located at the extremities of the Prefecture. These earthquakes, however, are recorded by the 20 intensity substations within the Prefecture. The mean annual number of earthquakes felt at these intensity substations has been calculated. Using these figures together with instrumental data, the details of the seismicity of the region are worked out. In some cases it is shown that the published epicenters should be shifted by as much as several kilometers when the intensity data are taken into account. This demonstrates the importance of the intensity reports in seismicity studies. It is urged that the intensity substations, now not always working efficiently, be strengthened throughout Japan (see also Geophys. Abs. 179-60). — D. B. V.

- 186-151. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 3. Temporary seismological network in the neighborhood of Wakayama [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 609-635, 1959.

Instrumental and intensity observations reported in the first two parts of this work (see Geophys. Abs. 179-60 and 186-150) have suggested that seismic activity of the Kii Peninsula is concentrated along the coast between Wakayama and Gobo, and that the earthquakes are very shallow. Temporary seismological networks were established in the neighborhood of Wakayama in order to locate the focuses as accurately as possible and to investigate the geological implications of such supracrustal seismicity.

Special highly sensitive electronic seismographs had to be developed to record these very local earthquakes at more than 4 stations, as required for focal determination by the S-P method. Even then the number so recorded was very limited. The results show that the highest activity is near Wakayama and Kainan, and that shocks there may originate at depths of only a few km. — D. B. V.

- 186-152. Miyamura, Setumi. Local earthquakes in Kii Peninsula, Central Japan. Pt. 4. Location of earthquakes by the temporary network of stations near Wakayama (in Japanese with English summary): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 71-112, 1960.

Data obtained by the temporary seismic network on the Kii Peninsula in 1952-56 were analyzed in order to locate the epicenters of the shallow shocks occurring in that region. The geographic distribution of the epicenters is shown in a sketch map. In the northern three-fourths of the area, no earthquakes originated at depths greater than 10 km and many were extremely shallow. Focal depths seem to be somewhat deeper in the south, but owing to the small number of origins determined in that area, definite conclusions would be premature. No earthquakes were located with focal depths between 10 and 14 km; this suggests the possibility of a plastic asthenosphere in the crust.

Data and results of P- and S-arrival time analysis and S-P interval analysis for the 1956 observations by the least squares and by the simultaneous equations methods, and of S-P interval analysis for the 1952-54 observations by the graphical method are tabulated in full in English. (See also Geophys. Abs. 179-60, 186-150, -151.) — D. B. V

- 186-153. Kogan, S. D., Pasechnik, I. P., and Sultanov, D. D. Seysmicheskiye nablyudeniya v Antarktike [Seismic observations in Antarctica]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 231-237, 1961.

An interpretation of the results of seismic observations at the Russian seismic stations Mirnyy and Oasis in Antarctica from June 1956 to December 1959 are presented. The distribution of earthquake epicenters is compared with the geology of Subantarctica. On the basis of dispersion curves of Rayleigh and Love waves, a continental type crust is established for eastern Antarctica, and an oceanic type for the region situated between Antarctica and the ring of alpine folded structures encircling this continent. — Authors' abstract, A. J. S.

- 186-154. Buffington, P. G. Earthquake insurance in the United States—a reappraisal: Seismol. Soc. America Bull., v. 51, no. 2, p. 315-329, 1961.

For the benefit of seismologists, some of the major problems confronting the earthquake insurance underwriter are discussed and areas in need of further research and study are pointed out. The underwriter would be aided by more detailed information on individual earthquakes including specific information on the type of construction damaged, type of ground on which it was built, total dollar damage, and estimate of property values in high damage areas. Also needed is further evaluation of the relationship between intensity and frequency of occurrence and better analysis of damage caused by earthquakes of various intensities. — D. B. V.

MacDonald, G. J. Seismic activity of the moon. See *Geophys. Abs.* 186-87.

186-155. Ben-Menahem, Ari, and Båth, Markus. A method for determination of epicenters of near earthquakes: *Geofisica Pura e Appl.*, v. 46, p. 37-46, 1960.

A method is described that permits rapid and reliable determination of near epicenters (within 10°), using the differences in arrival times of a phase (usually S_g) common to a network of three stations. The equation for computing epicentral distances is solved numerically by an electronic computer for every triangle of stations and for all possible time differences for each wave used, and the results are arranged in tables which provide an immediate solution of the problem in each individual case.

The method is not intended to replace but to supplement other methods. Its accuracy is discussed, and precautions necessary in its use are emphasized. The method is then applied to some S_g records from Swedish stations by way of illustration. — D. B. V.

186-156. Val'dner, N. G. Godograph voln L_1 , L_{g_1} , L_{g_2} , R_g [The traveltime curve of waves L_1 , L_{g_1} , L_{g_2} , and R_g]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 882-888, 1961.

The records of about 200 earthquakes were analyzed in a study of L_1 , L_{g_1} , L_{g_2} , and R_g waves, and the L_g and R_g data were used for determination of epicentral distances. Distinct records of arrivals on the seismograms and a relatively short period of oscillation (2-10 sec) are characteristic for L_g and R_g waves that can propagate through an undisturbed granitic layer only. Sharp arrivals of L_g and R_g waves were found on 140 records, 6 of which are shown in the paper. Epicentral distances of several earthquakes were determined from traveltime curves constructed for L_g and R_g waves and found to be in satisfactory agreement with the epicentral distances determined by other methods. — A. J. S.

186-157. Kuznetsov, V. P. Godograf zemletryaseniy yugo-vostochnogo Kavkaza [Traveltime curve of earthquakes of southeast Caucasus]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 889-891, 1961.

Traveltime curves constructed for earthquakes in the southeast Caucasus were found to be inaccurate for epicenter determinations. A correction for these traveltime curves is introduced. — A. J. S.

186-158. Andreyev, S. S. Primeneniye epitzentralay pri neizvestnom skornom razreze [Use of epicentrals with an unknown velocity section]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 7, p. 966-976, 1961.

Epicentral lines determined from the true traveltimes of seismic waves, when the velocity section is unknown, pass through the center of a circumference drawn through 3 stations. The coordinates of these epicentral lines with regard to the stations are determined by the value of the ratio K of the differences of the squares of the time. These K -epicentrals are used instead of epicentrals drawn according to the parameter q —the ratio of differences of the arrival times at the three stations. It was found that the K -epicentral method is more practical than the q -epicentral method when the small transformation error (from q to K epicentral lines) can be disregarded. — A. J. S.

- 186-159. Vvedenskaya, A. V., and Ruprekhtova, L. Osobennosti napryazhenogo sostoyaniya v ochagakh zemletryaseniya u izgiba Karpatskoy dugi [Features of the stress state at the focuses of earthquakes at the bend of the Carpathian Arc]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 953-965, 1961.

Analysis of distribution of stresses based on the theory of deformation forces as a symmetrical second rank tensor applied to the rupture and shear plane of an earthquake hypocenter is carried out for the earthquakes at the bend of the Carpathian Arc. The analysis shows that the compression forces in that region are almost parallel to the horizontal plane and act normally to the bend of the arc, whereas the tensile and intermediate forces are in the plane whose line of intersection with the earth's surface is tangential to the arc and coincides in strike with the axes of mountain folds in the region. The result obtained suggests a homogeneity in the tectonic structure of the region up to a minimum depth of 150 km. This is the depth of the hypocenters of the earthquakes analyzed. A further conclusion is made that the same forces that determine the relief and tectonics act also at the focuses of the earthquakes investigated. — A. J. S.

- 186-160. Vvedenskaya, A. V. K diskussii po povodu teoreticheskoy modeli ochaga zemletryaseniya [Discussion on a theoretical model of an earthquake focus]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 261-263, 1961.

This is a summary of Vvedenskaya's earlier published hypothesis of focal mechanism (see Geophys. Abs. 166-80, 172-142, 173-76, 183-142). A theoretical model is constructed based on a system of forces at the source that determine a symmetrical tensor of the second order of stresses at every point of the strained plane area at the source. — A. J. S.

- 186-161. Miyamoto, Sadao. Determination of the depth of earthquake hypocenter by means of Δ -PS curve [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 39-54, 1961.

The depth of the hypocenter of an earthquake can be determined from the P-S time at the epicenter estimated from its Δ -PS curve. Standard Δ -PS curves to be used for this purpose are presented. Many examples are given to show that this method of depth determination is superior to other methods. — V. S. N.

Hiersemann, L[othar]. Seismotectonics in the domain of young orogens. See Geophys. Abs. 186-363.

- 186-162. Belotelov, V. L., and Kondorskaya, N. V. O sootnoshenii mezhdu energiyey zemletryaseniya i maksimal'noy skorost'yu kolebaniy v ob"yemnykh volnakh [On the correlation between the energy of an

earthquake and the maximum rate of oscillations in body waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 38-45, 1961.

The relationship between the energy of an earthquake and the maximum oscillation rate of longitudinal and transverse waves is discussed. The values of the energy obtained earlier (see Geophys. Abs. 182-115) are compared with the values obtained with Gutenberg's formulas (see Geophys. Abs. 111-6710, 166-78, 167-68). It was found that $\log E = 11.8 + 1.5M$, in agreement with Gutenberg's formula. The maximum ratio of amplitude to period $(A/T)_{\max}$ is studied for deep and surface earthquakes; agreement is found with the result obtained in previous investigations, that is, $(A/T)_{\max}$ decreases with distance at a rate less than is expected. An attempt is made to explain this difference by an assumption that the absorption coefficient of body waves decreases with depth. — A. J. S.

- 186-163. Miyamoto, Sadao. The mean radius of felt area is better than the maximum radius for earthquake classifications [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 29-32, 1961.

It is shown that because the seismic intensity at stations in a region of abnormal gravity is abnormal also, the mean radius of a felt area is better fitted for the classification of earthquakes than is the maximum radius. — V. S. N.

- 186-164. Miyamoto, Sadao. Relation between the magnitude and radius of felt area of earthquakes [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 33-38, 1961.

It is shown that in the case of large earthquakes ($M > 7$), magnitude can be estimated from the mean radius of the felt area. — V. S. N.

- 186-165. Berg, G. V., and Housner, G[eorge] W. Integrated velocity and displacement of strong earthquake ground motion: Seismol. Soc. America Bull., v. 51, no. 2, p. 175-189, 1961.

Earthquake ground accelerations recorded at El Centro, Calif., on December 30, 1934 and May 18, 1940; at Olympia, Wash., on April 13, 1949; and at Taft, Calif., on July 21, 1952 have been integrated with a digital computer to obtain at each location the three components of ground velocity and ground displacement. Maximum horizontal displacements of 10 and 20 in. and maximum vertical displacements of 5 in. are indicated. — D. B. V.

- 186-166. Stauder, William, and Adams, W[illiam] M[ansfield]. A comparison of some S-wave studies of earthquake mechanisms: Seismol. Soc. America Bull., v. 51, no. 2, p. 277-292, 1961.

Graphical and analytical techniques for using S-waves in focal mechanism studies are compared. In previous applications the analytical method has shown little or no agreement with the results of fault plane solutions from P-waves, whereas for other groups of earthquakes the graphical methods have shown good agreement between S-waves and P-wave solutions. It is shown that both techniques are identical in principle and when applied to the same three earthquakes yield identical results.

Closer examination of the graphical presentation of the data shows that the disagreement between the S-waves and the fault plane solutions from P is largely apparent. Once it is understood that the discrepancy stems from the peculiar scatter in the S-wave data and the chance occurrence of observations of S at stations located along closely parallel planes of polarization of S, it is

seen that the direction of polarization of S-waves is in substantial agreement with the methods of analysis of focal mechanisms from P-waves, and that the data are consistent with a simple dipole as the point model of the earthquake focus. — D. B. V.

- 186-167. Shirokova, Ye. I. O napryazheniyakh deystvyushchikh v ochagakh zemletryaseniy Sredney Azii [On the stresses acting at the focuses of earthquakes in central Asia]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 876-881, 1961.

From the study of seismograms of 12 earthquakes of $M > 5$ in central Asia from 1954 to 1958 and from the determination of displacement fields in P- and S-waves caused by these earthquakes, two possible fault planes at the earthquake focuses, their displacements relative to each other, and the orientation of the main stress axes were determined. The compressive stresses were almost perpendicular to the strike of the mountain ridges and had a large horizontal component. The axes of tensile stresses were largely vertical. One of the possible fault planes coincides with the strike of the ridges and other large geologic features. — A. J. S.

- 186-168. Ichikawa, M. On the mechanism of the earthquakes in and near Japan during the period from 1950 to 1957: Geophys. Mag. [Tokyo], v. 30, no. 3, p. 355-403, 1961.

The mechanism of 43 earthquakes that occurred in and near Japan during 1950-57 has been investigated, mainly on the basis of first motions of P-waves. The relations between distribution of focuses, directions of maximum pressure and tension, strikes and dips of fault planes, and directions of fault movement and of the null vector have been analyzed statistically. It is found that the directions of the horizontal component of maximum pressure are nearly perpendicular to the trend of the Japan Trench and the seismic zones. The directions of maximum tension of deep and intermediate earthquakes are nearly parallel to the trench, whereas for shallow earthquakes they are almost perpendicular to the trench in central Honshu and nearly parallel to it in western and north-eastern Honshu. For the vertical component of maximum pressure there are two patterns, the first almost perpendicular to the trend of the vertical distribution of earthquake focuses and the second nearly parallel to it. These patterns agree with Honda's results (see Geophys. Abs. 170-48, -55). — D. B. V.

- 186-169. Bogdanoff, John L., Goldberg, John E., and Bernard, M. C. Response of a simple structure to a random earthquake-type disturbance: Seismol. Soc. America Bull., v. 51, no. 2, p. 293-310, 1961.

A physically plausible second order random function is selected to represent ground acceleration. Several member functions are presented in graphical form. Some of the statistical properties of the response of a simple structure to this acceleration are determined, and possible uses of these properties by designers of aseismic structures are discussed. To render the random function approach, as outlined here, useful to such designers, records of earthquakes at given places must be analyzed statistically and continually corrected as new earthquakes occur; the analysis presented here must be extended to multistoried structures; and simple approximate expressions for the probabilities of failure must be obtained. — D. B. V.

- 186-170. Sato, Yasuo, and Yamaguchi, Rinzo. Coupling effect of shear vibrations of the structure with elastic foundations, and the maxi-

imum response of the rocking motion [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 3, p. 127-140, 1960.

The shear vibration of a continuous circular column excited by ground motions is discussed. The coupling effect of the vibrating body and the elastic foundation is taken into account, and the calculations are based on the theory of Toriumi (1955). Maximum values of the response curves of rocking motion are given taking various values of the ratio (density of structure)/(density of foundation). Empirical formulas are presented that are true for the parameters giving maximum response. — V. S. N.

- 186-171. Yamaguti, Seiti. On the changes of heights of mean sea-levels, before and after the great earthquakes: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 145-175, 1960.

The monthly mean sea levels observed at different mareographic stations in Japan over periods ranging from 5 to 60 yr were corrected, smoothed, and plotted against the months on a diagram that also shows the months of great earthquakes ($M \geq 7$) at epicentral distances of >200 , >300 , >400 , and >500 km. The results show that sea level fluctuations began about 6 months before and reached a maximum about 4 months before and a minimum about 1 or 2 months before a great earthquake. In many cases mean sea levels were negative in the month of the earthquake.

Yearly mean sea levels were similarly plotted. There is no apparent increase in sea level height, only a slight 18-yr fluctuation about the secular mean of 40 yr. The apparent increase in the total mass of ocean water noted by oceanographers would probably vanish if their results were corrected for oceanic and meteorologic tides; a small subsidence of the crust relative to mean sea level would probably be observed on some coasts. — D. B. V.

- 186-172. Kanai, Kiyoshi. An empirical formula for the spectrum of strong earthquake motions: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 85-95, 1961.

One of the empirical formulas developed in a previous paper (see Geophys. Abs. 176-62) is improved and applied to 1 Japanese and 19 United States earthquakes for which strong-motion observations are available. Three equations are derived (for spectral displacement in cm, for velocity in cm per sec, and for acceleration in cm per sec²), applicable to the determination of ground motion characteristics for purposes of structural design. The magnitudes and epicentral distances of anticipated earthquakes may be estimated from seismicity statistics, and thus an approximate spectrum of seismic waves in bed rock can be obtained. If this spectrum is combined with the vibration characteristics of the ground at the structure, the lateral force coefficient can be determined. — D. B. V.

- 186-173. Kanai, Kiyoshi, and Tanaka, Teiji. On microtremors. VIII: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 97-114, 1961.

The results of systematic measurements of microtremors at thousands of places in Japan (see Geophys. Abs. 164-251, 171-297) show that these disturbances, chiefly of artificial origin, have a period distribution curve at any given place that reflects the local nature of the ground and are similar to earthquake motions at that place. Therefore, microtremor measurement is useful not only for anticipating the features of destructive earthquake motions but also for determining the seismic force coefficient to be considered in earthquake-proof construction design. — D. B. V.

- 186-174. Tanabashi, Ryo. On the safety of structures against earthquakes: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 35, 19 p., 1960.

The relation between the grade of damage to engineering structures and the nature of the ground in an area affected by an earthquake is discussed for 9 major Japanese earthquakes that have occurred since January 1924. Results indicate that except for shallow focus local earthquakes, the specific frequency of seismic wave found to predominate in an earthquake area depends upon the property of the ground. To develop criteria on the grade of damage to be expected in various areas, the elastic properties of the ground in areas of known damage have been investigated by seismic surveys and the results applied to other areas. Contour maps of probable future damage have been made for cities such as Kyoto, Osaka, and Nagoya.

A table showing percentage of damage to structures of various types in the Tokyo earthquake of 1923 is presented, and the significant factors in the mechanical properties of building materials necessary to ensure safety against seismic action are discussed. Earthquake-resistant designs should require that a structure be able to store a potential energy greater than $\frac{1}{2}MV^2$ for an assumed velocity of probable ground motion. Various examples are given, and the types of building materials most suitable for Japan are discussed. — V. S. N.

- 186-175. Tanabashi, Ryo. Earthquake resistance of traditional Japanese wooden structures: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 40, 15 p., 1960.

The natural earthquake resistance of the Japanese pagoda and of the traditional and modern Japanese wooden structures is analyzed. It is shown that the safety of a structure in an earthquake depends both upon its strength in a lateral direction and upon its ability to absorb a large amount of deformation. It is important that the period of vibration of the structure be longer than that of the ground acceleration to prevent the possibility of resonance with the ground acceleration waves. — V. S. N.

- 186-176. Goto, Hisao, and Kaneta, Kiyoshi. Analysis with an application to aseismic design of bridge piers: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 41, 17 p., 1960.

The response of a bridge pier on an elasto-plastic foundation subjected to idealized, transient ground motions has been analyzed theoretically by using an electronic analog computer equipped with a nonlinear backlash element to simulate the specific vibration system. The results indicate the great importance of consideration of damping capacity as well as ground-motion duration and acceleration in the aseismic design of bridges; in current aseismic design criteria only the maximum value of earthquake acceleration is taken into account. — V. S. N.

- 186-177. Austin, Charles R. Earthquake fluctuations in wells in New Jersey: New Jersey State Dept. Conserv. and Econ. Devel. Div. of Water Policy and Supply, Water Resources Circ. 5, 13 p., 1960.

About 200 sudden fluctuations of well water levels as observed since 1950 on records of water-stage recorders in 38 wells in New Jersey have been correlated with earthquakes. A table lists the wells with their geographic and geologic location and the number of fluctuations observed for each. These earthquake fluctuations range in amplitude from a trace to 2.66 feet, and the

magnitudes of the earthquakes are generally >7.0 . Disturbances have been caused by shocks of magnitude <7 , but in all such cases the epicenters were relatively close to New Jersey. The study of earthquake fluctuations in wells is relatively new, and new methods for determining geologic formations, faults, and density of materials may result if the program is intensified. — V. S. N.

Gougenheim, André. Confirmation by observation of the negligible role of the earth tide in the production of earthquakes. See *Geophys. Abs.* 186-221.

- 186-178. Eaton, J[erry] P., Richter, D. H., and Ault, W[ayne] U. The tsunami of May 23, 1960, on the island of Hawaii: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 135-157, 1961.

The tsunami of May 23, 1960, caused by the Chilean earthquakes, resulted in the greatest natural disaster in Hawaii since the Aleutian-born tsunami of 1946. Study of the T-phases from the earthquakes suggests that the duration of faulting responsible for the largest earthquake and the tsunami was about 7 min. The waves of the tsunami and the destruction caused by them are described.

It is concluded that earthquake waves generated by a crustal disturbance capable of producing a tsunami reach Hawaii minutes after the disturbance and carry vital data permitting calculation of origin time, location, and magnitude of the earthquake, and that the seismogram can also give valuable evidence on depth, proximity to the ocean, and nature of fault movement. Every effort should be made to achieve fullest interpretation of the seismogram in order to establish the likelihood and possible size of a tsunami. Location of the origin seems to be one of the major factors in determining which areas will be most affected by a tsunami and how great the damage might be. Tsunami with about the same geographic origin produce remarkably similar wave-height patterns that differ only in relative amplitude, whereas those from different regions produce contrasting patterns. Empirical ratios between wave heights at critical gaging stations and average measured wave heights for various sections and localities on Hawaii appear to offer the best basis for tsunami wave-height forecasting. — D. B. V.

- 186-179. Gilmour, A. E. Tsunami warning charts: *New Zealand Jour. Geology and Geophysics*, v. 4, no. 2, p. 132-135, 1961.

Two charts have been constructed to assist in predicting the travel times of tsunami waves reaching the New Zealand coast from known origins. If the time and location of the generating earthquake are known, the initial wave arrival times at various points on the coast lying in the direct path of the tsunami can be estimated within a time of approximately one hour. — Author's abstract

- 186-180. Ochapovskiy, B. L. Ob organizatsii na Dal'nem Vostoke spetsializirovannykh stantsii sluzhby tsunami [On the organization of the specialized stations of the tsunami service in the Far Eastern Region]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 9, p. 5-6, 1961.

The plans for a tsunami warning system in the Far Eastern Region of the U. S. S. R. are described briefly. — D. B. V.

- 186-181. Popov, G. I. Ob usloviyakh obrazovaniya tsunami [On the conditions of formation of tsunami]: *Akad. Nauk SSSR Sovet po Seysmologii Byull.*, no. 9, p. 7-22, 1961.

The results of investigations in the U. S. S. R., Japan, and elsewhere concerning the conditions that give rise to tsunami are reviewed. — D. B. V.

- 186-182. Solov'yev, S. L., and Ferchev, M. D. Svodka dannikh o tsunami v SSSR [Summary of data on tsunami in the U. S. S. R.]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 9, p. 23-55, 1961.

This is a catalog of tsunami that have occurred in the U. S. S. R. (Far Eastern Region) since 1737. — D. B. V.

- 186-183. Brune, James N., Benioff, Hugo, and Ewing, Maurice. Long-period surface waves from the Chilean earthquake of May 22, 1960, recorded on linear strain seismographs: Jour. Geophys. Research, v. 66, no. 9, p. 2895-2910, 1961.

Phase and group velocities of mantle Love and Rayleigh waves obtained from strain seismograph records of the Chilean earthquake are presented. The velocities of mantle Rayleigh waves of period from 300 to 550 sec agree with those predicted from periods of free spheroidal oscillation of the earth and do not show a flattening of the group velocity curve for periods greater than 380 sec. Group velocities for mantle Rayleigh waves reach a maximum of 7.8 km/sec at a period of about 1,000 sec. Study of initial phases of Rayleigh waves indicates a difference of phase of π between the azimuth to Isabella and the azimuths to Ñaña and Ogdensburg. Determinations of phase and group velocities of Love waves have been extended to periods of 700 sec. The phase velocity data of Sato [see Geophys. Abs. 174-61] have been corrected for the polar phase shift. The correct curve has been identified from the numerous possible curves which result from a 2π ambiguity in the phase correlation made by Sato. Values of phase velocities are presented for periods in the range of 60-700 sec. The group and phase velocities of both Love and Rayleigh waves agree well with those predicted for the Gutenberg-Bullen A model of the earth. It is verified that analysis of seismograms in terms of progressive wavetrains is equivalent to analysis in terms of standing waves. In the presence of ad-sorption, as for the earth, the analysis in terms of progressive wave trains has many advantages. — Authors' abstract

- 186-184. Alsop, Leonard E., Sutton, George H., and Ewing, Maurice. Measurement of Q for very long period free oscillations: Jour. Geophys. Research, v. 66, no. 9, p. 2911-2915, 1961.

The radical amplitude variation with time of long-period spectral peaks corresponding to the periods of free oscillation [see Geophys. Abs. 184-187] is explained. It arises from the rotation of the corresponding standing wave pattern with respect to the earth. The modulation caused by this rotation imposes certain conditions on the length of record and the interval between records used to measure Q by observing the amplitude decrement. Under these conditions the Q for the ${}_0S_2$ mode is measured to be 370, and for the ${}_0T_5$ mode, Q is measured to be about 300. These values are contrasted with other values of Q obtained by various authors for other free periods. Q appears to be constant for modes ${}_0S_2$ through ${}_0S_9$. — Authors' abstract

- 186-185. Takeuchi, H[itoshi], and Kobayashi, N[aota]. Free spheroidal oscillations of the earth: Seismol. Soc. America Bull., v. 51, no. 2, p. 223-225, 1961.

Free periods of the earth's spheroidal oscillations are calculated for the wave numbers n up to 16; the earth's sphericity, self-gravitation, and a liquid

core are taken into account. Period-wave number and period-phase number velocity relations are shown in graphs. — D. B. V.

- 186-186. Backus, George, and Gilbert, Freeman. The rotational splitting of the free oscillations of the earth: [U.S.] Natl. Acad. Sci. Proc., v. 47, no. 3, p. 362-371, 1961.

In the Fourier spectrums of records of the free oscillations of the earth excited by the Chilean earthquakes of May 1960 (see Geophys. Abs. 181-119, 184-183) some of the observed peaks appeared to be double or triple, the components being separated by as much as two minutes and the theoretical line falling approximately at their mean position. This splitting is shown mathematically and quantitatively to be an effect of the diurnal rotation of the earth.

Agreement between the observed and predicted periods of the spheroidal spectral lines is very good. Failure of the records to show splitting of the torsional lines is probably due both to limited resolution and to natural broadening of the lines by dissipation. The observed amplitudes of excitation of the split lines remain to be explained. — D. B. V.

- 186-187. Jobert, Nelly. Calcul approché de la période des oscillations sphéroïdales de la Terre [Approximate calculation of the period of the spheroidal oscillations of the earth]: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 242-258, 1961.

The first part of this paper treats spheroidal oscillations of the earth in the absence of gravity. The effect of the core is considered and the exact solution is obtained for a sphere with a homogeneous liquid core and homogeneous solid mantle having the average properties of the earth's core and mantle, respectively. By application of the Rayleigh principle according to a method of Jeffreys, an approximate value of 66.3 min is obtained for the period of vibration for Bullen's model A.

In the second part gravitation is taken into account in a series of models of increasing complexity. Using the Rayleigh principle, an approximate value of 51.8 min is obtained for the period of vibration of Bullen's models A and B. — D. B. V.

- 186-188. Alterman, Z., Jarosch, H., and Pekeris, C. L. Propagation of Rayleigh waves in the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 219-241, 1961.

This is the same paper as that published in Rehovot, Israel, Weizmann Institute, Department Applied Mathematics, 11 p., 1961 (see Geophys. Abs. 184-184). — D. B. V.

- 186-189. Oliver, Jack [E.]. On the long period character of shear waves: Seismol. Soc. America Bull., v. 51, no. 1, p. 1-12, 1961.

S and multiple S phases at moderate to large epicentral distances are frequently followed by normally-dispersed long-period wave trains for which surface particle motion is elliptical and progressive and in the plane of propagation of the SV wave. The character of such phases can be explained as the result of coupling between the incident shear waves and dispersive PL waves in the near-surface wave guide. A detailed study of shocks in Mexico and in Montana recorded at Resolute, and less detailed studies of other data support this hypothesis. — Author's abstract

- 186-190. Nuttli, Otto [W.], and Whitmore, John D. An observational determination of the variation of the angle of incidence of P waves with

epicentral distance: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 269-276, 1961.

Apparent angles of incidence of the P-wave were obtained from seismograms of the Galitzin-Wilip instruments at Florissant, Colo. The "half-periods" of these waves ranged from $1\frac{1}{2}$ to $3\frac{1}{2}$ sec and the epicentral distributions from 16.5° to 103.2° . The data indicate that the velocity of P-waves at the earth's surface is about 8 km/s, suggesting that these P-waves do not see or are not affected by the crust. P-wave data for the Alaskan earthquake of July 1958 from 5 other stations throughout the world support these conclusions. — D. B. V.

186-191. Båth, Markus. Polarization of transverse seismic waves: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 106-123, 1961.

Changes in polarization of transverse waves during propagation through the earth are investigated. The polarizations have been computed theoretically and numerically for reflection at the core boundary and at the earth's surface, for refraction and reflection at the base of the crust, and for passages through continuously varying mediums. It is shown that great changes of vibration angle and particle orbit may occur in all cases except for continuously varying mediums; in these, transverse waves propagate practically unchanged.

Applied to earthquake mechanism studies using S-waves, these results mean that observations of direct S-waves are most trustworthy, and that in using ScS, sS, SS, or other transverse waves the changes of the vibration angle on reflection at the core boundary or earth's surface must be taken into account. — D. B. V.

186-192. Caloi, Pietro. Seismic waves from the outer and the inner core: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 139-150, 1961.

New formulas for the determination of seismic wave traveltimes in the interior of the earth are derived and applied to the calculation of traveltimes of ScS waves from the shallow Aegean earthquakes of April-June, 1957, which were recorded with exceptional clarity at the Tolmezzo seismic station. The same records also clearly showed PKiKP waves, reflected from the inner core. — D. B. V.

186-193. Hai, Nguyen. Propagation des ondes longitudinales dans le noyau terrestre d'après les séismes profonds des Iles Fidji [Propagation of longitudinal waves in the earth's core after the deep earthquakes of the Fiji Islands (with English and Russian abstracts)]: *Annales Géophysique*, v. 17, no. 1, p. 60-66, 1961.

Results of a study of the traveltime curves for longitudinal waves traveling through the earth's core from three earthquakes originating in the Fiji Islands at focal depths of 600 km are discussed. The most important result is the curve for the PKP1 phase which may be traced from 143° to 158° or 160° ; a table gives the corresponding duration of propagation of the phase. Other important phases are observed between 103° and 143° ; these are illustrated. — V. S. N.

186-194. Matumoto, Tosimatsu. On the spectral structure of earthquake waves. — The relation between magnitude and predominant period: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 1, p. 13-27, 1960.

Fourier analysis is applied to the P- and S-wave parts of records of 10 shocks that occurred in 1958 in a narrow belt off northeastern Honshu, Japan. The digitalized processing apparatus used for the analysis is described.

In each spectrum there are several maximums, and the periods (T) corresponding to these maximums are related to magnitude (M) as $M = \alpha_1 + \beta_1 \log T_1$ (where α_1 and β_1 are determined by the method of least squares). All branches of the P- and S-wave parts are more or less parallel to each other; this suggests that all predominant periods are related to the magnitude of the shock, and that the ratios of the predominant periods belonging to branch O and others are constant regardless of magnitude. These characteristics of predominant period are due clearly to the focal mechanism of the earthquake rather than to the nature of the ray path.

The different groups of predominant period are explained as oscillations of fundamental and higher modes, based on a spherical shell model. — D. B. V.

- 186-195. Brune, James N., Nafe, John E., and Alsop, Leonard E. The polar phase shift of surface waves on a sphere: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 247-257, 1961.

It has been demonstrated by means of a model experiment that elastic surface waves on a sphere advance in phase by $\pi/2$ on each crossing of the polar or antipodal region. Comparison of the asymptotic forms of solutions of the wave equation for displacements and dilatation before the polar crossing with those that apply afterward also show the $\pi/2$ phase shift. Similarly a $\pi/4$ phase advance occurs for waves leaving a point source.

Because of the occurrence of the polar phase shift, it is necessary to correct previously published Rayleigh and Love wave phase velocities measured by correlation of phases over complete circumferential paths. The corrected Rayleigh wave phase velocity curve is presented here.

The polar phase shift is involved in the determination of periods of free oscillation of the earth from surface wave data. Using data from the great Chilean earthquake of May 22, 1960, it is shown that the ratio of the earth's circumference to the wave length at free oscillation periods gives very nearly half integers in accordance with the formula $2\pi a/\lambda = n + 1/2$. — Authors' abstract

- 186-196. Kovach, Robert L., and Press, Frank. A note on ocean sediment thickness from surface wave dispersion: *Jour. Geophys. Research*, v. 66, no. 9, p. 3073-3074, 1961.

Objections raised by Evison and others (see *Geophys. Abs.* 185-364) to the use of Rayleigh wave dispersion data for estimating the thickness of unconsolidated sediments on the ocean floor are answered. Crustal thickness is shown to be a negligible factor. A more important source of error is the small but finite rigidity of the sediments. The range of sedimentary thickness found by dispersion analyses is 0.5-1 km, of the same order of magnitude as the typical range found by refraction measurements (0.2-1 km). The effect of irregular topography and contributions from nonbasin portions of the path cannot be determined; until dispersion data and refraction data are available for the same region, the ultimate precision of the method cannot be estimated. Surface wave methods are not meant to be competitive with explosion methods; however, they are the only source of information in remote oceans not covered by refraction surveys. — D. B. V.

- 186-197. Hochstrasser, Urs, and Stoneley, Robert [S.]. The transmission of Rayleigh waves across an ocean floor with two surface layers, pt. 2: Numerical: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 197-201, 1961.

Continuing the investigation of Rayleigh wave propagation along ocean paths (see also *Geophys. Abs.* 168-68), values are obtained for the wave velocity and group velocity of Rayleigh-type waves for 8 different models. In these models ocean depths are 4 or 6 km, the sedimentary layer is 1 or 2 km, and basic rocks are 5 or 7 km thick; in all cases these structures are assumed to rest on ultrabasic rocks of great thickness.

The wave velocity was found for a series of values of the wave-number by solving an eleven-row determinantal equation (using an electronic computer), and the corresponding group velocity values were obtained from these by numerical differentiation. The general agreement of these dispersion curves with observed values indicates their usefulness in determining the ray track and time of passage of a train of Rayleigh waves crossing an ocean floor whose structure and depth vary from place to place. — D. B. V.

186-198. Lehmann, I[nge], and Ewing, M[aurice]. On short-period surface waves as recorded in Copenhagen: [Denmark] *Geod. Inst. Skr.*, ser. 3, v. 34, 19 p. [with diagrams under separate cover, unpagged], 1960.

Records of 300 earthquakes at epicentral distances of 0°-60° obtained during 1921-53 at Copenhagen were examined carefully for traces of Lg. Because Lg (taken as a purely transverse wave) may be associated with longitudinal and vertical short-period wave groups arriving at the same time, the study was extended to the entire short-period wave train succeeding the forerunners.

Velocities were determined for the wave groups picked out in the record and plotted for each earthquake separately against period in a graph which also showed the Lamont second mode dispersion curve. For most earthquakes a certain number of points were close to the second mode dispersion curve. Most clearly in evidence were waves of rather long but indeterminate period in the first part of the train and groups of waves, sometimes quite strong, arriving with a velocity of 3.5 km/s or less. This is when Lg is supposed to arrive; but if Lg is taken to be purely transverse, this phase is not always very distinct. Most of the period-velocity points of the alleged Lg's are close to the dispersion curve, but they do not gather near its maximum as might be expected. This does not disprove that Lg forms part of the second mode train, but it suggests the possibility that Lg might be connected with the short-period branch of the first mode Love wave dispersion curve.

The vertical and longitudinal wave groups arriving at about the same time are often more conspicuous. Like the transverse Lg, they are indicative of continental structure. In some ways it would be more convenient to let Lg stand for the combined short-period phase rather than just the transverse wave. Several other short-period wave groups arriving earlier and later are not considered in this study. The greater complexity of the Copenhagen records compared to those of Palisades is attributed largely to the more complicated structures on the path.

Diagrams of 31 earthquakes are reproduced under separate cover; remarks on each of these diagrams draw attention to features of interest. — D. B. V.

186-199. Bulin, N. K., and Savarenskiy, Ye. F. O korotkoperiodnykh pov-
erkhnostnykh seysmicheskikh volnakh [About short-period sur-
face seismic waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6,
p. 855-863, 1961.

From study of experimental data on surface waves of 0.2-2.5 sec periods and group velocities of 280-800 m per sec recorded from explosions and earthquakes at distances 1-200 km and 70-250 km, respectively, it was established that such surface waves are connected with the top 10-20 m of the friable sed-

imentary layer. The results of the analysis carried out indicate the feasibility of using low group velocity surface waves in seismic prospecting (see also Geophys. Abs. 175-59). — A. J. S.

- 186-200. Kobayashi, Naota. Vertical distribution of amplitudes of the Rayleigh type dispersive waves (2d report) [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 241-258, 1960.

It is commonly believed that the particle orbit for M_{11} waves at the surface is retrograde to the direction of wave propagation. Kobayashi demonstrates that the particle orbit for waves with wavelengths longer than about $4.6H$ (H = thickness of the superficial layer) changes its rotational direction if the substratum is rigid; the M_{11} waves are classified into 2 groups on this basis. A similar complexity was found to be true also for the M_{21} dispersive-type Rayleigh waves. These complexities for both types of waves occur, however, only at and near the surface; the rotational direction of the particle orbit at a point in depth in the superficial layer is retrograde to the direction of wave propagation. (See also Geophys. Abs. 181-138.) — V. S. N.

- 186-201. Aki, Keiiti, and Nordquist, John M. Automatic computation of impulse response seismograms of Rayleigh waves for mixed paths: Seismol. Soc. America Bull., v. 51, no. 1, p. 29-34, 1961.

A program has been devised to compute theoretical seismograms of Rayleigh waves for a given epicenter and a given station entirely automatically on an electronic computer. The earth's surface is divided into three regions: continents, Pacific Ocean, and oceans other than the Pacific. Allowance can be made for differences in structure in these regions. This simple division seems satisfactory at present for Rayleigh waves of period longer than 35 sec. — Authors' abstract

- 186-202. Bolt, Bruce A. Machine processing of seismic travel-time data: Seismol. Soc. America Bull., v. 51, no. 2, p. 259-267, 1961.

A method of constructing empirical traveltimes curves from a sample of observed times has been programmed for an IBM 709 computer. The program processes up to 500 observations of the phase under revision, taken from any number of selected earthquakes. The focus and origin time of each shock are first adjusted by an automatic procedure previously described (see Geophys. Abs. 184-168) and the needed correction applied to the observed times. The corrected times are then weighted relative to a provisional traveltimes table, and the weights are used to fit polynomials up to a specified degree. Sample characteristics are also computed to facilitate statistical treatment.

Preliminary results obtained using the program to process PKIKP times from 9 Aleutian and 1 deep-focus New Zealand shock are presented. These results supply additional evidence that the Jeffreys-Bullen PKIKP times require the addition of about $1\frac{1}{4}$ sec relative to the standard P tables. — D. B. V.

- 186-203. Adams, William M[ansfield], and Allen, D. C. Reading seismograms with digital computers: Seismol. Soc. America Bull., v. 51, no. 1, p. 61-67, 1961.

A device that permits direct input of seismic traces into electronic digital computers is described. Examples of its use and its several merits are presented. The device makes feasible numerical analysis of data recorded in analog form on photographic film or paper. — Authors' abstract

- 186-204. Chakrabarty, S. K., and Tandon, A. N. Calibration of electromagnetic seismographs satisfying Galitzin conditions: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 111-125, 1961.

Theoretical results are given for the response of electromagnetic seismographs to different tests required in their calibration and to sinusoidal ground motion. The reaction of the seismometer and galvanometer is retained. Final results are given for the special types of seismographs in which the seismometer period and galvanometer period are equal and the galvanometer is critically damped. The variation of the magnification curve as well as that of the response to different tests with changes in the reaction and seismometer damping have been obtained. Methods are indicated for determining the instrumental constants and adjusting the seismographs to any prescribed condition. The results of calibration of a Sprengnether seismograph at Shillong, India, are given. The method suggested can also be used in the precise estimation of the instrumental constants and the magnification of Galitzin-type seismographs even in past operations, if routine test data (particularly the response to tapping test and sudden impulse test) are available. — D. B. V.

- 186-205. Cloud, W[illiam] K., and Hudson, D[onald] E[llis]. A simplified instrument for recording strong motion earthquakes: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 159-174, 1961.

A strong-motion earthquake recorder for the direct measurement of one point on the response spectrum curve is described, and results obtained with the instrument under field conditions are compared with those obtained by a standard spectrum analysis of accelerograph records. The device has the advantage of low initial cost and of low maintenance expense, and can thus be installed in relatively large numbers. A network of such instruments located at points having various local geological conditions is proposed as a supplement to the U. S. Coast and Geodetic Survey strong-motion seismograph system. — Authors' abstract

- 186-206. Willmore, P. L. Some properties of heavily damped electromagnetic seismographs: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 389-404, 1961.

The classical theory of electromagnetic seismographs is discussed with special reference to the properties of combinations of seismometer and galvanometer in which the damping of either or both components is very much greater than critical. The paper includes a graphical method of determining approximate response curves for such seismographs.

The treatment of passive systems is extended to cover cases in which the galvanometer light spot energizes a photoelectric amplifier, and in which the amplifier output is fed back into the mechanical system. Feedback through a seismometer produces new effects, which are discussed. An example is described to illustrate the value of the moving-coil galvanometer as an element in feedback seismographs for use in fixed stations; in conjunction with large damping coefficients, very wide-band response to ground velocity may be obtained. — D. B. V.

- 186-207. Alberta Society of Petroleum Geologists. A new instrument for recording earthquakes: *Alberta Soc. Petroleum Geologists Bull.*, v. 8, no. 8, p. 233, 1960.

A new type of seismometer developed by Carey and Newstead of the University of Tasmania is described briefly. The instrument consists of a pendulum

swinging from a frame well anchored to the earth; unlike the standard seismometer with a stylus attached to the frame and a recording instrument on the heavy pendulum, this instrument has a small pendulum suspended on a hinge. Induction currents are so arranged that as soon as there is a tendency for movement an equal and opposite current is directed to stop the motion; thus, the amount of damping is measured by the feedback. By setting up two instruments at right angles the direction of wave propagation can be observed. The instrument is small and has great sensitivity; when installed in a basement of a house it can pick up all vibrations in the vicinity. With the three instruments now in Hobart set to record all their movements on a single drum, the earthquake waves can be observed both in amplitude and direction. The recordings are continuous and true to the amount of movement at the exact time of movement. With a 12 pen high-speed drum recorder these Tasmanian instruments give records of many earth movements at any certain time—a "spectrum" of every instant. With such a continuous recording device the first small movements of larger earthquakes to come may be detected thus making it possible to issue warnings of impending earthquakes. The instrument may be used also for engineering purposes such as in tunnel construction and mining to warn of impending breakage. — V. S. N.

- 186-208. Weber, Max. P. G.-Seismographen und ihre Eichung [P.G. seismographs and their calibration (with English summary)]: *Geofisica Pura e Appl.*, v. 46, p. 26-32, 1960.

A contribution is made to the theory of pendulum-galvanometer seismographs. The construction and theory of a new calibration device involving horizontal and vertical shaking tables are described, and an example is given of the calibration of a Hiller-Askania seismograph. — D. B. V.

- 186-209. Weber, Max. Ein exakter Seismograph [An exact seismograph]: *Geofisica Pura e Appl.*, v. 48, p. 35-39, 1961.

The theory, construction, and characteristics of an exact seismograph, in which the new element is the rectifier-amplifier, are described. — D. B. V.

- 186-210. Lin'kov, Ye. M., and Tripol'nikov, V. P. Magnito-elektronnyy seysmograph [A magnetoelectronic seismograph]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 2, p. 259-260, 1961.

A simple and highly sensitive magnetoelectronic seismograph is described. It consists of a horizontal pendulum similar to a Kirnos horizontal seismograph. An annular magnet fastened to its end creates a magnetic field of approximately 200 oersteds along the axis. An electronic tube, fastened rigidly to the base of the seismograph, is situated outside the magnet. Electromagnetic damping is achieved by means of a coil in the field of the magnet. A schematic diagram of the circuit is given. This seismograph has a high sensitivity that is not dependent on amplitude. Such high sensitivity permits the seismic signals to be transmitted by radio. The instrument can be used to record seismic waves as well as to measure tilting of the surface. — J. W. C.

- 186-211. Feofilaktov, V. D. Kinstumental'nomu opredeleniyu energii seymicheskikh voln [Instrumental determinations of energy of seismic waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 412-417, 1961.

This paper describes and analyzes a three-component seismic energometer (see *Geophys. Abs.* 179-108) and its performance in recording energies of

earthquakes. The instrument is a velocimeter capable of galvanometric quadratic recording on a cinema film. The energogram appears as a transparent path of variable width which is proportional to the square of the "ground" oscillation, while the area is proportional to the time integral of that value. From earthquakes of 5.5 to 7.5 magnitude and epicentral distances of 20° to 160° recorded during 6 months by the Moscow State University seismograph station it was found that the values of energies given by the energographs are apparently the most accurate, although they are always higher than the energy values calculated from the seismogram of regular seismographs. — A. J. S.

- 186-212. Khristichenko, P. I. K voprosu ob uravnenii dvizheniya mayatnikovyykh seysmografov [On the problem of the equation of motion of pendulum seismographs]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 443-444, 1961.

Considering a pendulum seismograph as a bound system of a variable depending explicitly on time coupling, the motion velocity \bar{v}_a under the variable bond consists of two components: the translation velocity \bar{v}_e with the bond and the relative velocity \bar{v}_r within the system; \bar{v}_e is usually known and \bar{v}_r unknown, thus $\bar{v}_a = \bar{v}_e + \bar{v}_r$. Disregarding rotation motions of the reference system and differentiating according to t , the equation of acceleration can be written as $\bar{w}_a = \bar{w}_e + \bar{w}_r$. From this the force equation, $m\bar{w}_r = \bar{F} + (-m\bar{w}) + (-\beta\bar{v}_r) + (-\beta\bar{v}_e)$, can be written according to Newton's second law of motion, considering the resistance of the mediums to be proportional to the first power of velocity and β to be the resistance coefficient. The force $-\beta\bar{v}_e$ affects both the amplitude and phase of the seismic waves; however, it is not taken into account in theories of seismographs. A mathematical analysis of the force $-\beta\bar{v}_e$ is given, and a nonhomogeneous equation of Matieu type is derived for the correction of a seismograph error due to the omission of the force $-\beta\bar{v}_e$ in its equation of motion. — A. J. S.

- 186-213. Vinnik, L. P. O grupirovani nizkochastotnykh seysmografov [On grouping of low frequency seismographs]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 643-648, 1961.

Seismograph grouping and its application to a number of seismological problems that can be solved by the planar arrangement of seismographs are analyzed mathematically. A formula is derived for amplification and frequency characteristics of a seismograph in a group designed for direct galvanometric recording. — A. J. S.

- 186-214. Arkhangel'skiy, V. T., Kirnos, D. P., Popov, I. I., and Solov'yev, V. N. Opyt nablyudeniya dlinnoperiodnykh seysmicheskikh voln na stantsii Simferopol' [A test observation of long period seismic waves at the Simferopol station]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 670-675, 1961.

An experimental model of a vertical seismograph for recording waves of 20-300 sec periods is described, and the results of testing and the data of observed earthquakes are given. Rayleigh seismic waves of 160-480 sec periods from the Chilean earthquake of May 22, 1960 were recorded by this seismograph at the Simferopol station. In contrast to other seismographs which could not record the arrival of P-waves, the new seismograph recorded the diffracted P-wave as an isolated impulse of 35 sec period. At 14,000 km from the epicenter, the extra long seismic waves (about 1,000 km) produced 0.5 cm ground displacement. — A. J. S.

- 186-215. Fremd, V. M. Vspomogatel'naya apparatura seysmicheskikh stantsiy severnogo Tyan'-Shanya [Auxiliary equipment of seismic stations of northern Tien Shan]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 744-747, 1961.

Auxiliary equipment for automatic controlling, signaling, and operating seismographs at the central seismic station at Alma-Ata in the northern Tien Shan is described. The equipment consists of a unit for automatic increase in filament heating, oversensitivity reduction, and signaling. Circuit and block diagrams are given, and the operation and maintenance of the apparatus is discussed. — A. J. S.

- 186-216. Kirnos, D. P., and Rykov, A. V. Spetsial'naya bystrodeystvuyushchaya seysmicheskaya apparatura dlya opoveshcheniya o tsunami [Special fast-acting seismic apparatus for announcing tsunami]: Akad. Nauk SSSR Sovet po Seysmologii Byull., no. 9, p. 56-66, 1961.

Russian devices designed to determine the epicenter and intensity of an earthquake within 3 or 4 min after its beginning are described and illustrated. The UBOPE-1 apparatus was constructed at the Geophysical Institute in 1954-55 and installed at Petropavlovsk-Kamchatka, Klyuchi, and South Sakhalin in 1955. It consists of two sets of devices, an azimuthograph to show the direction of the epicenter and a seismograph (SMR-3) to show the epicentral distance and intensity of an earthquake. This apparatus is intended to give warning of catastrophic tsunami. The UBOPE-2 was developed in 1957 at the Institute of Earth Physics. The principle is similar to that of UBOPE-1 but the seismograph and azimuthograph are of different design, intended to register earthquakes of medium intensity.

Data obtained with the UBOPE-1 in the earthquakes of November 7, 1958 and May 4, 1959 suggest that the magnification of the SMR-3 seismograph should be reduced from $V_0=5$ to about $V_0=1$; the period and damping, and the parameters of the azimuthograph need no change for the present. — D. B. V.

- 186-217. Matumoto, Hideteru. Transistor pre-amplifier for a seismograph [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 525-530, 1959.

A transistor preamplifier designed for a highly sensitive electronic seismograph is described; wiring diagrams, graphs of frequency characteristics, and a photograph of the preamplifier and transducer are given (with English captions). Reproductions of seismograms obtained with an Hagiwara electromagnetic short-period seismograph and with an electronic seismograph equipped with the transistor preamplifier show that with the latter, the stability and sensitivity for minor shock observations are greater than previously attained with ordinary electronic seismographs. — D. B. V.

- 186-218. Shima, Etsuzo. Theoretical and experimental approach to the designs and calibrations of electro-magnetic seismograph. Pt. 1. Voltage sensitivity of the moving-coil type seismometer: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, no. 1, p. 29-39, 1960.

Almost all electromagnetic seismometers of recent design are of moving-coil (with fixed magnet) or moving-magnet (with fixed coil) type, both types being the same theoretically. In this paper an equivalent four-terminal network of such instruments is deduced mathematically. It agrees with the one suggested by Sherbatskoy and Neufeld (1937). With this equivalent circuit the

instrumental constants of a seismometer can be determined easily by measuring the motional impedance electrically, when the voltage sensitivity is known. The equivalent circuit can also be used in consideration of a galvanometer by reversing the input and output.

A simple zero-method for measuring voltage sensitivity more precisely than previously possible is described. Motional aspects of the voltage sensitivity are not treated; they will be dealt with in the next paper. — D. B. V.

- 186-219. Yazaki, K. Earthquake occurrence time recorder [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 26, no. 1, p. 1-5, 1961.

A new instrument designed to record automatically the time of earthquake occurrence is described and illustrated. It is composed of a signal filter, control gates, second-pulse clock, hour-minute counter, second counter, printing hammer, delivery roller of printed paper, and reset pulse generator. It works in liaison with the observatory clock to show the hour. — V. S. N.

- 186-220. Willmore, P. L. The new seismograph station at Resolute, Northwest Territories: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 5, p. 101-111, 1960.

In 1957, the Dominion Observatory seismograph station at Resolute, N. W. T., was replaced by a larger station with modern instrumentation. The new station contains three seismographs of short period, three of intermediate period, and three of long period. The construction of the station and the procedure for setting up the instruments are described. Calibration curves for all the instruments are included. — Author's abstract

EARTH TIDES AND RELATED PHENOMENA

- 186-221. Gougenheim, André. Confirmation, par l'observation, du rôle négligeable de la marée terrestre dans la production des séismes [Confirmation by observation of the negligible role of the earth tide in the production of earthquakes]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 21, p. 3313-3314, 1961.

The time distribution of 19 relatively recent earthquakes widely scattered throughout the globe was compared to earth tide curves. No correlation was found between the amplitude of the earth tide and the occurrence of earthquakes. When premonitory shocks, main shocks, and aftershocks were considered separately, only half or less than half of each type of shock occurred near an extremum of earth tide. It is concluded that the tensions due to earth tides are too slight to trigger earthquakes. — D. B. V.

- 186-222. Defant, Albert. *Physical oceanography*, v. II: New York and London, Pergamon Press, 598 p., 1961.

The periodic movements of water masses that occur in the form of waves, tides, and related phenomena are discussed in this second volume of the textbook on physical oceanography. The text includes 16 chapters and is divided into two parts: (1) surface and long waves, and (2) tides and tidal currents. Part 2 includes a chapter on tides in relation to geophysical and cosmic problems in which the effect of the ocean tides on the solid earth is discussed. The detection of tides in the solid earth from tidal observations in shallow adjacent seas and the deformations of the solid earth by tidal load are treated. — V. S. N.

- 186-223. Munk, Walter [Henrich], and Hassan, El Sayed Mohamed. Atmospheric excitation of the earth's wobble: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 339-358, 1961.

The excitation of the seasonal and 14-month (Chandler) wobble is discussed on the basis of mean monthly values of the atmosphere's movements and products of inertia for the period 1873-1950. The calculations confirm the conclusion of Jeffreys and others that the seasonal wobble is due largely to atmospheric excitation, but the amplitudes obtained are 25 percent smaller than those given by Jeffreys (see Geophys. Abs. 179-250).

The computed spectral density of the atmospheric variation at the Chandler frequency falls short by one or two orders of magnitude of meeting the requirement of the hypothesis that the Chandler wobble represents a resonance amplification of the irregular (nonseasonal) variation in atmospheric inertia. Excitation by irregular motion in the core is considered; the electromagnetic coupling appears to be far too weak to account for the observed wobble. The case of the Chandler wobble is an unsolved problem. — D. B. V.

- 186-224. Fedorov, E. [Ye.] P. Nutation as derived from latitude observations: Astron. Jour., v. 64, no. 3, p. 81-84, 1959.

This is the same as the paper published in Astron. Zhur., v. 36, no. 5, p. 914-918, 1959 (see Geophys. Abs. 180-78). — D. B. V.

- 186-225. Jeffreys, Harold. Nutation and the variation of latitude: Astron. Jour., v. 64, no. 3, p. 84-86, 1959.

This is the same as the paper published in Astron. Zhur., v. 36, no. 5, p. 918-920, 1959 (see Geophys. Abs. 180-77). — D. B. V.

- 186-226. Munk, Walter H[enrich], and MacDonald, Gordon J. F. The rotation of the earth: Cambridge, University Press, 323 p., 1960.

An account is given of certain irregularities in the rotation of the earth which are not ordinarily included in the gravitational theory; these include irregularities in rate of rotation and in position of the axis that are caused by events on and in the earth. Such events can be effectively studied by means of measured irregularities. It is the purpose of this book to make this method of study readily accessible to the geophysicist. The 12 chapter headings are as follows: precession, nutation, and wobble; dynamics; deformation; Love numbers and associated coefficients; solutions to the approximate Liouville equation; observations of latitude; observations of the length of day; seasonal and other short-period variations; Chandler wobble; historical variations; and geological variations. A bibliography of over 300 entries is included. — V. S. N.

- 186-227. Schatzmann, Evry. Sur la théorie de Holmberg de l'entretien de la rotation terrestre [On Holmberg's theory of the maintenance of the earth's rotation]: Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 26, p. 4413-4414, 1960.

The relaxation time of the earth's rotation, connected with the semidiurnal wave of the atmosphere, is calculated to be of the order of 3×10^5 yr. Holmberg's mechanism for maintaining the period of the earth's rotation can operate rapidly only if the amplitude ratio is much larger than appears possible. Therefore, the second order terms found by Danjon in the variation of the period of rotation (see Geophys. Abs. 181-375) do not stem from this mechanism. — D. B. V.

- 186-228. Melchior, Paul [J.]. Les relations entre les mouvements du pôle et les fluctuations de la vitesse de rotation de la Terre [The relations between movements of the pole and fluctuations of the velocity of rotation of the earth (with discussion)]: *Astron. Jour.*, v. 64, no. 3, p. 86-95, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 920-933, 1959 (see *Geophys. Abs.* 180-74). — D. B. V.

- 186-229. der Waerden, B. L. van. The irregular rotation of the earth: *Astron. Jour.*, v. 64, no. 3, p. 96-97, 1959.

A mechanical explanation of the observed irregular rotations of the surface of the earth is proposed. From this probabilistic model the correlations between the apparent fluctuations of the motion of the moon in successive years are derived and a modified least-squares method is derived for finding the secular variation of sun and moon. — Author's abstract

- 186-230. Brouwer, Dirk. Fluctuations and secular changes in the earth's rotation: *Astron. Jour.*, v. 64, no. 3, p. 97-99, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 933-935, 1959 (see *Geophys. Abs.* 180-75). — D. B. V.

- 186-231. Stoyko, Nicolas. Variations périodiques et aléatoires de la rotation de la Terre [Periodic and aleatory variations of the earth's rotation]: *Astron. Jour.*, v. 64, no. 3, p. 99-102, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 938-943, 1959 (see *Geophys. Abs.* 181-148). — D. B. V.

- 186-232. Danjon, A[ndré]. Variation progressive et variation saisonnière de la rotation de la Terre [Progressive and seasonal variation of the rotation of the earth]: *Astron. Jour.*, v. 64, no. 3, p. 102-103, 1959.

This is a preliminary report on the results of a comparison of universal time, deduced from astrolabe observations at the Paris observatory, and uniform time furnished by the cesium standard of Essen and others (see *Geophys. Abs.* 173-117). The observed and calculated seasonal variations from 1956.5 to 1958.5 are compared graphically; the differences do not appear to be systematic. — D. B. V.

- 186-233. Nemiro, A. A., and Pavlov, N. N. The influence of systematic errors of star catalogs on the determination of the irregularities of the earth's rotation: *Astron. Jour.*, v. 64, no. 3, p. 103-106, 1959.

In order to lessen the influence of the errors in the right ascensions of stars of fundamental systems on the results of time determinations, it is proposed that the results of time services observing with transit instruments be used for the determination of an independent system of right ascensions of stars. The participation in this work by a maximum number of observatories in different countries is desirable. — D. B. V.

- 186-234. Markowitz, W[illiam]. Variations in rotation of the earth, results obtained with the dual-rate moon camera and with photographic zenith tubes: *Astron. Jour.*, v. 64, no. 3, p. 106-113, 1959.

This is the same as the paper published in *Astron. Zhur.*, v. 36, no. 5, p. 949-958, 1959 (see *Geophys. Abs.* 181-149). — D. B. V.

- 186-235. Woolard, Edgar W. Inequalities in mean solar time from tidal variations in the rotation of the earth: *Astron. Jour.*, v. 64, no. 4, p. 140-142, 1959.

The deformation of the earth by the luni-solar tide-generating forces alters the moments of inertia of the earth and thereby causes periodic variations in the rate of rotation, which introduces inequalities in the measure of time determined by the rotation. The cumulative effects of the larger long-period components with period up to one year have been detected by observations with the aid of accurate clocks. In this paper, all long-period inequalities with amplitudes as great as 0.10 millisecond are computed and are listed in a table. — Author's abstract

ELASTICITY

- 186-236. Latter, Albert L., Martinelli, E. A., Mathews, J., and McMillan, W. G. The effect of plasticity on decoupling of underground explosions: *Jour. Geophys. Research*, v. 66, no. 9, p. 2929-2936, 1961.

The effect of plasticity, including work hardening, on seismic decoupling of underground explosions has been studied for large spherical cavities designed to give maximum decoupling and for small (overdriven) cavities designed to give partial decoupling. An important result is that plasticity plays no role in explosions in large cavities, even those at great depth for which some plastic flow occurs during construction of the cavity. For small cavities at great depth plasticity affects the decoupling factor by an amount depending upon the degree of overdriving, the depth, and the detailed stress-strain relation of the medium. A further result is that for cavities at a depth of about 1 km in a medium like salt, which exhibits work hardening, the decoupling factor is at least as great as that obtained in the overdriven Cowboy experiments and could be appreciably greater. It is also concluded that the depth of the cavities in the Cowboy experiments was not sufficient for plastic flow to occur in the salt medium before other inelastic behavior, e. g., cracking, set in. A simplified model of the Cowboy inelasticity is discussed. [See also *Geophys. Abs.* 184-259, -260, -261]. — Authors' abstract

- 186-237. Haskell, Norman A. A static theory of the seismic coupling of a contained underground explosion: *Jour. Geophys. Research*, v. 66, no. 9, p. 2937-2944, 1961.

According to the theory of Latter, Martinelli, and Teller [see *Geophys. Abs.* 178-369] the amplitude of the distant seismic signal from a completely contained underground explosion is determined by the permanent displacement produced in the neighborhood of the source. A static-equilibrium theory of this displacement is developed. A Coulomb-Mohr type of yield condition is used to determine the stresses in the near zone where the stresses are beyond the elastic limit. If the internal friction parameter that occurs in the Coulomb-Mohr yield condition is treated as a phenomenological constant, to be determined by the seismic data, it is possible to obtain reasonably good agreement with the relative amplitudes of the seismic signals observed in the Project Cowboy series of chemical explosions in cavities of various sizes in salt. The indicated value of the friction parameter is, however, appreciably

less than the values usually observed in compression tests on unconsolidated materials. The theory is also consistent with the observed size of the cavity produced in tuff by the underground nuclear explosion Rainier, but an even smaller value of the friction parameter must be assumed in this case. — Author's abstract

- 186-238. Adams, W. S., and Carder, D[ean] S. Seismic decoupling for explosions in spherical cavities: *Geofisica Pura e Appl.*, v. 47, p. 17-29, 1960.

A series of paired explosions in a salt mine near Winnfield, Louisiana, has been conducted to test the theory of Latter and others (see *Geophys. Abs.* 184-259) concerning seismic decoupling by underground cavities. The theory predicted decoupling of about 100. Freefield and surface measurements from an explosion in either a 6-ft- or a 15-ft-radius spherical cavity were compared with similar measurements from a completely tamped explosion. Shot sizes were from 20 lb up to a few tons. Surface measurements were made out to 100 km and covered the frequency range 0.5-100 cycles per sec. The results are in sufficiently good agreement with the theory to suggest its general validity. There would appear to be no reason why corresponding results would not be obtained for nuclear explosions in the frequency range of interest for detecting clandestine nuclear tests. — D. B. V.

- 186-239. Dix, C. H[ewitt]. The seismic head pulse, reflection and pseudo-reflection pulses: *Jour. Geophys. Research*, v. 66, no. 9, p. 2945-2951, 1961.

The shapes of the seismic head pulse, the ordinary reflection and pseudo-reflection pulses are compared with the direct pulse shape. The direct pulse in the step in the radial displacement potential. The method used is a variation of Cagniard's work together with suitable approximations. The results are contained in Cagniard's original work. The present treatment is simpler than Cagniard's and better adapted to direct numerical calculations for many important cases. A numerical example is given. — Author's abstract

- 186-240. Anderson, Don L. Elastic wave propagation in layered anisotropic media: *Jour. Geophys. Research*, v. 66, no. 9, p. 2953-2963, 1961.

This is an analysis of the dispersive properties of transversely isotropic media. This kind of anisotropy is exhibited by hexagonal crystals, sediments, planar igneous bodies, ice sheets, and rolled metal sheets where the unique axis is perpendicular to the direction of surface wave propagation and the other axes are distributed randomly in the plane of the layers. Period equations are derived for waves of Rayleigh, Stoneley, and Love types, and comparisons are made, in certain cases, with ray theoretical and plane stress solutions. Anisotropy can have a pronounced effect on both the range of existence and the shape of the dispersion curves and can lead to an apparent discrepancy between Love and Rayleigh wave data. Attention is focused in this initial paper on a single solid layer in vacuo (i. e., a free plate) and a solid layer in contact with a fluid halfspace. The single layer solutions are generalized to n-layer media by the use of Haskell matrices. — Author's abstract

- 186-241. Knopoff, Leon, and Gilbert, Freeman. Diffraction of elastic waves by the core of the earth: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 35-49, 1961.

The problem of the diffraction of a seismic pulse by the core of the earth is investigated theoretically. The result is compared to that of diffraction by a half-plane. The differences are striking. Laboratory model experiments have been performed to verify the theoretical approximations in their regions of validity, and to complement the theory elsewhere. The curves, thus obtained, of the theoretical amplitude distribution in the shadow of the earth's core agree very well with the observations of Gutenberg. It is therefore concluded that diffraction is a completely adequate explanation for the amplitude distribution in the shadow zone. — Authors' abstract

- 186-242. Nuttli, Otto [W.]. The effect of the earth's surface on the S wave particle motion: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 237-246, 1961.

Expressions are derived for the motion of a plane free surface of the earth due to the incidence of plane harmonic S-waves of arbitrary polarization and incidence angles. For angles of incidence less than $\sin^{-1}(b_0/a_0)$, where a_0 and b_0 are the P- and S-wave velocities at the surface, all three components of ground motion will be in phase and the resultant motion is linear. For angles of incidence greater than $\sin^{-1}(b_0/a_0)$ all three components will in general be out of phase, and the resultant motion describes some three-dimensional figure. The epicentral distance at which the motion changes from linear to nonlinear depends on the wave length of the S-wave and the slope of the traveltime curve at that distance. — D. B. V.

- 186-243. Brekhovskikh, Leonid M. Waves in layered media: New York, Academic Press, 561 p., 1960.

A systematic presentation of the theory of the propagation of elastic and electromagnetic waves in layered media is given. The text has been translated from Russian, and although it is not restricted to Russian work in the field, it does present a complete picture of Russian researches on wave propagation through layered media. The following chapters are included: plane waves in layers, some applications of the theory of plane wave propagation in layered media, plane waves in layered-inhomogeneous media, reflection and refraction of spherical waves, wave propagation in layers, and the field of a concentrated source in a layered-inhomogeneous medium. — V. S. N.

- 186-244. Pekeris, C. L. Propagation of seismic pulses in layered liquids and solids, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 45-57, 1960.

The application of computer techniques to shallow-water propagation is discussed with reference to the existing types of computers, as well as to the supercomputers to be available in the next decade. The problem of sound propagation from a periodic point source and that of explosive sound propagation in a two-layered liquid are considered solved on existing computers. However, when the three-layered case is considered or when rigidity of the bottom is included in the two-layered case a super computer is required to reduce the time of computation to a few hours. Illustrations are given of the solution on WEIZAC of explosive wave propagation problems in two-layered liquids, and a comparison is made with a previous solution obtained by normal mode theory. The nature of the problems in the field of propagation to be solved in the future is discussed. — V. S. N.

- 186-245. Bullen, K. E. Seismic ray theory: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 93-105, 1961.

Seismic ray theory is developed initially with special emphasis on the variables ξ and α , (where $\xi = d \log v / d \log r$ and $\alpha = 2/(1-\xi)$). Traveltime-distance relations are examined for a variety of types of velocity distribution, including the case where α and v change discontinuously, or rapidly but continuously, with increasing depth. This analysis should provide an improved basis for working out in qualitative detail the effect on traveltimes of types of velocity variation relevant to the earth. In particular it is hoped that the analysis will lead to more effective use of ray theory in the current difficult problems of outer mantle structure.

Some previous results involving ξ and α are presented in revised form as part of a wider logical development. Previous work on deriving seismic velocity distributions from traveltime data is generalized.

Nonnumerical applications are given, but references are given to papers containing such applications. — D. B. V.

- 186-246. Baumgarte, J., and Krey, T[heodor]. Reflexion und Brechung beim schrägen Durchgang ebener seismischer Wellen durch N planparallele Medien [Reflection and refraction of plane seismic waves on oblique propagation through N plane-parallel mediums (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 2, p. 242-260, 1961.

The problem of propagation of an obliquely incident periodic longitudinal plane wave through $(n+2)$ homogeneous, isotropic, plane parallel layers with both longitudinal and transverse waves occurring in each medium is investigated mathematically. It is shown that a general solution can be given explicitly, using only 4-row and 4-column matrices. The two-layer problem must be solved in its very general form, and from this the solution of any multilayer problem can be derived. The method is clear and concise, and also yields correct solutions in the case where the critical angle of total reflection for longitudinal or transverse waves is exceeded in one or more mediums.

Two special cases important in refraction seismology are given special attention: the case where the longitudinal waves of medium 1 assumed the critical angle, and the case where the transverse waves of medium t assume the critical angle.

The treatment begins by calculating the considerably simpler reflection and refraction in optics, then investigates the relatively simple seismic case of an incident transverse wave polarized at right angles to the common plane of refraction, and finally calculates the principal case of longitudinal seismic waves occurring in common with transverse waves polarized in the plane of refraction. — D. B. V.

- 186-247. Schulz, Gerhard. Über ein Refraktionsproblem [On a refraction problem (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 5, p. 236-245, 1960.

The amplitudes of plane elastic waves generated by grazing incidence at an interface are calculated and set in relation to the amplitude of the primary wave that is refracted to produce the grazing incidence. — Author's abstract

- 186-248. Chakraborty, Sakti Kanta. Disturbances in a viscoelastic medium due to impulsive forces on a spherical cavity: *Geofisica Pura e Appl.*, v. 48, p. 23-26, 1961.

The disturbances produced in a viscoelastic medium by impulsive forces on the surface of a spherical cavity within the medium are treated mathematically. — D. B. V.

- 186-249. Riznichenko, Yu. V., and Shamina, O. G. O mnogokratnykh otra-zhennykh i prokhodyashchikh volnakh [Multiple reflected and transmitted waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1689-1706, 1960.

The intensities of diffuse reflected and impulse transmitted seismic waves in a multilayered medium are calculated on the basis of the theory proposed by Riznichenko (see Geophys. Abs. 180-372). Model experiments, conducted with the aid of an impulse ultrasonic apparatus in a tank containing a liquid medium and solid models of layers (see Geophys. Abs. 152-14284), essentially confirm the theory and provide additional information on the forms and periods of the waves and on their changes after multiple reflection and passage through a multilayered medium. — A. J. S.

- 186-250. Ogurtsov, K. I. Outochenii asimptoticheskikh otsenok intensivnosti volny, rasprostranyayushcheyasya v parallel'nosloistoy uprugoy srede [Accuracy improvement of asymptotic evaluations of wave intensity traveling in an elastic medium of parallel layers]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 224-230, 1961.

The problem of finding an approximate optimum evaluation of the intensity of waves propagating through an elastic medium composed of parallel layers is treated mathematically. The asymptotic solution is given with two first terms, and conditions that permit the second term to be disregarded without loss of accuracy are discussed. Formulas derived are simplified for the case where one of the links of a seismic ray makes a small angle with an interface; then the second term of the formula becomes important. — A. J. S.

- 186-251. Riznichenko, Yu. V., Shamina, O. G., and Khanutina, R. V. Uprugie volny s oboshchennoy skorost'yu v dvumernykh bimorfnykh modelyakh [Elastic waves of generalized velocity in two-dimensional bimorphic models]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 497-519, 1961.

Formulas are derived for the velocities of long longitudinal and transverse waves in thin bimorphic and polymorphic plates in two-dimensional modeling of seismic waves. Experiments with bimorphic models confirm the accuracy of the long-wave theory and establish its limitations. If the thickness of a bimorphic plate is considerably smaller than the wavelength, generalized P-, S-, and R-waves can propagate within them. Attenuation of longitudinal and transverse waves in bimorphic plates conforms to the same laws as in monomorphic plates. Experiments with a gradient medium demonstrate that even with such an insignificant variation in velocity with depth that it cannot be detected by traveltime curves, the amplitude characteristics of longitudinal waves are very sensitive to changes. — J. W. C.

- 186-252. Pod'yapol'skiy, G. S. Koeffitsiyent prelomleniya i otrazheniya uprugikh voln na sloye [Indices of refraction and reflection of elastic waves at a layer]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 520-533, 1961.

The indices of refraction and reflection are taken to be the so-called displacement coefficients, which can be defined as the ratios of the length of the vector displacements in the reflected or refracted waves to the lengths of the vector displacements in the incident waves, where the length of a vector is taken to be positive or negative depending on the sign of its projection on the X-axis. Formulas are derived for calculating the refraction and reflection

indices of elastic waves at a layer of constant thickness. These formulas are given in particular in terms of the refraction and reflection coefficients at the boundaries of a layer. The coefficients are treated as operators that transform the waveforms and their frequency patterns. — J. W. C.

- 186-253. Osipov, I. O. Otrazheniye i prelomleniye ploskikh uprugikh voln na granitse dvukh anizotropnykh sred [Reflection and refraction of plane elastic waves at the boundary of two anisotropic mediums]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 649-665, 1961.

The problem of reflection and refraction of plane elastic waves at the interface of 2 anisotropic mediums of 3 elastic constants is discussed. After a mathematical analysis of a planar dynamic problem of propagation of elastic waves in anisotropic mediums, the waves are divided into two types. Changes of elastic velocity in halite, sylvite, pyrite, and fluorite for both types of waves are analyzed. The analysis is also applied to Rayleigh boundary waves. — A. J. S.

- 186-254. Usami, Tatsuo. Some remarks on the solutions of the equation of motion in an isotropic and homogeneous elastic body—Especially on the uniqueness of the solutions for boundary value problems in an infinite elastic medium [in Japanese with English abstract]: Zisin, ser. 2, v. 14, no. 1, p. 18-28, 1961.

The equation of motion of an elastic medium expressed in vector form makes it clear that there are several different solutions which satisfy the condition $\Delta=0$; eight different expressions are derived in this paper. By using one of these solutions two independent solutions are given for a problem of motion in an infinite elastic medium when displacements (or stresses) are given for the wall of a cavity in that medium. — V. S. N.

- 186-255. Bolt, Bruce A., and Dorman, James. Phase and group velocities of Rayleigh waves in a spherical, gravitating earth: Jour. Geophys. Research, v. 66, no. 9, p. 2965-2981, 1961.

Periods of spheroidal eigenvibrations, with order of spherical harmonic $n \geq 20$, have been computed for self-gravitating inhomogeneous spheres corresponding to a variety of earth models, and then used to deduce phase and group velocities for the fundamental and first higher modes of Rayleigh waves of periods < 320 sec. The mathematical methods, program checks, and estimations of accuracy are presented in some detail. A comparison is made between phase and group velocities for different spherical models and with corresponding flat earth velocities calculated for the same physical parameters. The comparison shows that the inclusion of gravity and sphericity increases the phase velocity by about 5 percent near $T=300$ sec and by about 2.5 percent near $T=150$ sec. The group velocities for the spherical case remain within 1 percent of the corresponding velocities of the horizontally layered case for $100 < T < 250$ sec.

The variation with depth of the relative amplitudes of the radial and horizontal displacements and the perturbed gravitational potential is shown graphically for one earth model in the cases $n=30, 80$, and 110 . Comparison with these theoretical results shows that recent observations are consistent with a mantle having a density distribution similar to that of Bullen's model A, and P- and S-velocity distributions similar to those calculated by Gutenberg.

A group velocity dispersion curve corresponding to the first higher mode (or first shear mode) of Rayleigh waves has also been computed for $20 < T < 150$ sec ($500 > n > 40$) for a continental model. The minimum and maximum of this

curve occur at a velocity of 4.30 km/s and period of 60 sec and at a velocity of 4.54 km/s and period 25 sec, respectively; the period and velocity of the latter agree well with those of the Sa phase described by Caloi (see *Geophys. Abs.* 161-100) and Gutenberg (see *Geophys. Abs.* 161-99) and of the Sn phase of Press and Ewing (see *Geophys. Abs.* 160-97). — D. B. V.

- 186-256. Lapwood, E. R. The transmission of a Rayleigh pulse round a corner: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 174-196, 1961.

The form of a Rayleigh pulse after it passes around a corner is investigated mathematically. The problem is treated as two-dimensional, the pulse traveling on one face of an elastic quarter-space and the crest-line being parallel to and traveling toward the edge. It is found that the form of the pulse is changed greatly, depending on the P-, S-, and R-wave velocity values. Whereas the displacements u and v on $y=0$ have the shape of $\phi(t)$ and its allied function $\phi'(t)$, respectively, each of u and v on $x=0$ is given by a linear combination of ϕ and ϕ' . Since ϕ' may differ greatly from ϕ in form, the change in shape of each component of displacement when it turns the corner may be very marked. — D. B. V.

- 186-257. Nag, K. R. On the propagation of Rayleigh waves in three dimensions in alluvial soils: *Geofisica Pura e Appl.*, v. 48, p. 16-22, 1961.

The propagation of Rayleigh waves in three dimensions in alluvial soils that do not behave as ordinary isotropic elastic solids is treated mathematically. The frequency equation is solved for different soil constants. — D. B. V.

- 186-258. Takeuchi, Hitoshi, and Saito, Masanori. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 4). A computer program for the computation of Rayleigh-dispersion on the homogeneous multilayered media [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 4, p. 227-231, 1960.

Phase and group velocities of Rayleigh waves are obtained on the Bendix G-15D computer for a specified wave length for up to 20 homogeneous solid layers. A liquid layer lying on the solid layers may be taken into account. (See also *Geophys. Abs.* 181-134, 184-225, 186-262). — V. S. N.

- 186-259. Deresiewicz, H. The effect of boundaries on wave propagation in a liquid-filled porous solid: 2. Love waves in a porous layer: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 51-59, 1961.

The transcendental equation is derived relating frequency and phase velocity of propagation of Love waves in a porous layer containing a viscous liquid. This equation, being complex, can be satisfied only if the wave number of the motion is complex, indicating that the disturbance is dissipative. The general expression being intractable analytically, an approximate scheme is employed to determine the phase velocity and measure of dissipation valid for porous materials in which the mass (per unit volume of aggregate) of the interstitial liquid is smaller than that of the solid. — Author's abstract

- 186-260. De Noyer, John. The effect of variations in layer thickness on Love waves: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 227-235, 1961.

A model is considered in which Love waves propagate perpendicular to the trend of a structure that varies in thickness as a sine function of distance. The period equation for this model is obtained and average values for phase and group velocities are found for several distance ranges. A method is proposed for finding relative amplitudes as a function of position along the structure for any specified period. This approach can also be applied to arbitrary crustal structures other than sinusoidal, as long as the thickness of the upper layer and the slope of the interface are continuous single-value functions and the thickness of the upper medium remains positive; the first and second derivatives of the wave number k with respect to horizontal distance x must also be small.

A solution for dispersion of Rayleigh waves propagating across a similar type of structure may permit more reliable interpretation of crustal structures than has been possible with the "average" thickness concept. As more long-period seismographs are put into service, it may become practical to use surface wave amplitude data along with group and phase velocities for the determination of crustal structure. — D. B. V.

- 186-261. Knopoff, Leon. Green's function for eigenvalue problems and the inversion of Love wave dispersion data: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 161-173, 1961.

The change in the nature of the dispersion curve for Love waves has been determined for the case of a delta function inhomogeneity introduced at depth. The unperturbed medium is arbitrarily inhomogeneous in the depth dimension. It is shown that the perturbations in the dispersion curves due to a density inhomogeneity are decoupled from those due to a modulus inhomogeneity. Hence it is proved that any dispersion curve can correspond to an infinity of possible distributions of density and modulus; the relation between the possible solutions is given by a linear integral equation. The inversion of the integral equations is carried out for the case when the starting values are those of the usual homogeneous layer overlying a homogeneous half-space. Hence from a given dispersion curve, the infinity of solutions are obtained as perturbations upon the assumed starting structure. The limitations of the inversion are discussed. — Author's summary

- 186-262. Takeuchi, Hitoshi, and Saito, Masanori. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 3). A computer program for the computation of Love wave dispersion on the homogeneous multi-layered media [in Japanese With English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 219-226, 1960.

A program for the Bendix G-15D computer prepared by Press and Takeuchi to calculate Love wave dispersion using Haskell's matrix iteration method (see Geophys. Abs. 152-14273) is discussed. The phase and group velocities obtained correspond to a specified wave length of Love wave for up to 39 homogeneous solid layers lying on a homogeneous solid half-space. [See also Geophys. Abs. 181-134, 184-225.] — V. S. N.

- 186-263. Kobayashi, Naota, and Takeuchi, Hitoshi. Surface waves propagating along the free surface of a semi-infinite elastic medium of variable density and elasticity (pt. 5). Mantle Love waves [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 232-240, 1960.

Using the variational calculus method developed in previous papers (see Geophys. Abs. 175-254, 181-134, 184-225, 186-258, and 186-262), the man-

the Love-wave problem is studied for the model earths of Jeffreys and Gutenberg. Contrary to the corresponding mantle Rayleigh wave problem, the Jeffreys' model gives better agreement with observations of mantle Love waves than does the Gutenberg model. — V. S. N.

- 186-264. Sato, Yasuo. Analysis of dispersed surface waves, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 303-327, 1960; Japanese version in *Zisin*, ser. 2, v. 13, no. 3, p. 163-192, 1960.

The study and analysis of dispersed surface waves is aimed at a knowledge of (1) the structure of the medium through which the waves are being propagated, and (2) the mechanism of the source which radiates the disturbance into this medium. A general survey of the different methods of analysis starting from observed data is first presented, with special emphasis on direct methods for obtaining the structure of the medium. These are the use of the WKB-approximation, and a high-speed iterative computation procedure. The use of Fourier analysis is also discussed, and examples shown based on data from natural and from artificial disturbances. — Author's abstract

- 186-265. Kumar, Sudhir. Edge waves in plates, in *International symposium on stress wave propagation in materials*: New York and London, Interscience Publishers, Inc., p. 119-131, 1960.

The waves recorded at the edge of a plate when a certain stress is propagating in the plate are termed here "edge waves." In the present paper, the boundary value problem of propagation of edge waves in a flat plate of specified width and infinite length has been solved. The plate with free edges is assumed to be thin, and the external forces are taken as acting in the plane of the plate in order to make the problem one of plane stress. The frequency equation of propagation is obtained, and some limiting cases of the frequency equation are then discussed. Finally, the similarity of one of the two frequency equations for edge waves in a plate with the frequency equation for flexural waves in a plate is pointed out. — Author's abstract

Brune, James N., Nafe, John E., and Alsop, Leonard E. The polar phase shift of surface waves on a sphere. See *Geophys. Abs.* 186-195.

- 186-266. Keylis-Borok, V. I. *Interferentsionnyye poverkhnostnyye volny* [Interference surface waves]: Moskva, Akad. Nauk SSSR Inst. Fiziki Zemli, 195 p., 1960.

This is a monograph on the specific oscillations of elastic mediums known variously as surface waves, natural oscillations of layers, normal waves, guided waves, interference waves, and the like. The generalized physical-mathematical treatment of the subject permits investigations for an arbitrary number of layers of an arbitrary nonsymmetrical, nonstationary, and arbitrarily situated oscillation source. Only flat-parallel, homogeneous, isotropic, and ideally elastic layers are discussed. Applications of the theories to problems of the constitution of the earth, engineering seismology, seismic exploration, seismic regionalization, oceanography, meteorology, and recognition of nuclear explosions are discussed. A bibliography of 106 titles is given. — A. J. S.

- 186-267. Birch, Francis. The velocity of compressional waves in rocks to 10 kilobars, pt. 2: *Jour. Geophys. Research*, v. 66, no. 7, p. 2199-2224, 1961.

The measurements of the velocity of compressional waves up to 10 kilobars for some 250 specimens of rock, reported in part 1 [see *Geophys. Abs.* 184-227], are discussed with respect to the effects of porosity, alteration, anisotropy, and composition. The relations of isotropic elasticity are shown to be approximately valid for a number of examples. Reasonable agreement with theoretical values for quasi-isotropic aggregates is demonstrated where comparison is possible. At pressures above a few kilobars, the principal factors determining velocity are density and mean atomic weight; oxides and silicates conform to the same general relations, with a few exceptions. Details of symmetry or crystal structure appear to be of secondary importance. Velocity is an approximately linear function of density for materials having a common mean atomic weight, but is in general not a single-valued function of density alone. — Author's abstract

- 186-268. Roever, W. L., Vining, T. F., and Strick, E. Propagation of elastic wave motion from an impulsive source along a fluid solid interface. Pt. 1. Experimental pressure response; Pt. 2. Theoretical pressure response; Pt. 3. The pseudo-Rayleigh wave: *Royal Soc. London Philos. Trans.*, v. 251, no. 1000, p. 455-523, 1959.

The pressure response for the impulse-excited fluid-solid interface problem was investigated experimentally by means of a pressure wave generated in the system by a spark and detected with a small barium titanate probe, the output of which was displayed on an oscilloscope and photographed. Two cases were investigated: one where the transverse wave velocity is lower than the longitudinal wave velocity in the fluid, and the other where it is higher. Both observed responses agree even as to details of wave-form with exact theoretical calculations made for a delta-excited line source. In the case of low transverse wave velocity one finds a Stoneley type of interface wave in addition to critically refracted P, direct, and reflected waves; a Stoneley wave thus may be the largest contributor to a response curve. In the case of high transverse wave velocity the critically refracted P-wave is smaller and the Stoneley wave becomes compressed in time and arrives very soon after the reflection. Between the critically refracted P-wave and the direct arrivals there is a pressure build-up preceding the arrival time that might be expected for a critically refracted transverse wave.

The pressure build-up is investigated and found to consist of the superposition of three arrivals. Most prominent of these is the pseudo-Rayleigh wave; the others are the critically refracted transverse wave and the build-up to the later arriving Stoneley wave. The pseudo-Rayleigh wave has the velocity of a true Rayleigh wave and the same retrograde particle motion, but mathematically it originates from a pole lying in a lower Riemann sheet in the complex plane rather than from a pole on the real axis of the plane of the variable of integration. The migration of this complex pole explains why such a pseudo-Rayleigh wave was not observed in the low transverse velocity case.

Finally, a method is suggested for obtaining the solid rigidity of bottom sediments in watercovered areas from measurements in place of the pseudo-Rayleigh and (or) Stoneley wave velocities and arrival times. — D. B. V.

- 186-269. Müller, Gerhard. Geschwindigkeitsbestimmungen elastischer Wellen in gefrorenen Gesteinen und die Anwendung akustischer Messungen auf Untersuchungen des Frostmantels an Gefrierschächten [Velocity determinations of elastic waves in frozen rocks and the application of acoustic measurements to investigations of the frozen belt at frozen shafts (with English abstract)]: *Geophys. Prosp.*, v. 9, no. 2, p. 276-295, 1961.

Acoustic velocity measurements were made on synthetic frozen cores in order to determine the applicability of such measurements to the method of sinking mine shafts through unfavorable ground by freezing during sinking. The validity of the laws of sound propagation through unfrozen porous mediums is extended to temperatures below the freezing point of water. Measurements in place demonstrate that the elastic wave velocity of solid rocks increases considerably on freezing.

It is concluded that such measurements in shafts can supply important information concerning the structure and thickness of the frozen belt, changes in stability of the rock due to freezing, and the planning of temporary and final shaft lining. A four-page bibliography is given. — D. B. V.

- 186-270. Balakrishna, S. Ultrasonic velocities in some metamorphic rocks: *Geol. Soc. India Jour.*, v. 1, p. 136-143, 1959.

Sound velocities, both longitudinal and torsional, are measured in some metamorphic rocks by the ultrasonic pulse method. Results show that changes in physical structure of the rock, too slight to make a measurable difference in density, are capable of changing the modulus of extension by a large factor. Velocity varies linearly with change in grain size; it decreases as grain size increases. Moreover, the ultrasonic velocities in metamorphic rocks decrease rapidly with increasing temperature, and the temperature gradient for longitudinal velocities is greater than for torsional ones. The temperature gradient in metamorphic rocks is controlled mostly by the degree of metamorphism and consequent compaction and, therefore, by their petrogenetic history. [See also *Geophys. Abs.* 175-96, 179-130, 182-170, 185-160.] — V. S. N.

- 186-271. Pros, Zdeněk, and Vaněk, Jiří. Experimental study of a pulse method for measuring elastic parameters of rocks in samples: *Československá Akad. Věd Studia Geophys. et Geod.*, v. 4, no. 4, p. 338-349, 1960.

The pulse method variant using two electroacoustic transducers is particularly suitable for measuring elastic parameters of rocks. Two principal arrangements of this variant are the transmission method, in which the transmitter and receiver are placed on opposite faces of the sample, and the profiling method, in which the transmitter is on one face or on the surface and the receiver is moved over the surface of the sample. The transmission method is more reliable in the case of longitudinal wave velocity and permits the determination of both P- and S-wave velocities in a single measurement. As a relatively complicated wave pattern consisting of several wave groups is observed in this method, a thorough knowledge of the wave pattern and changes in its geometry in the sample is necessary for interpretation of the results. Also, the plane wave approximation usually used in computing velocities cannot be realized in many cases.

This paper investigates these questions in detail. The wave patterns generated by a plane wave in a cylindrical sample, by a point source in a cylindrical sample, and by a source of infinite dimensions in a cylindrical sample are examined theoretically; methods of determining the wave velocities from the wave patterns are discussed; and then the results are generalized for samples of shapes other than cylindrical. With the aid of the detailed classification of observable wave groups and with the use of smaller transducers and the generalized results given here, the applicability and reliability of the transmission method are greatly enhanced. — D. B. V.

- 186-272. Rykunov, L. N., Khorosheva, V. V., and Sedov, V. V. Dvukhmer-naya model' seysmicheskogo volnovoda s nerezкими granitsami

[Two-dimensional model of a seismic wave guide with diffuse boundaries]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 11, p. 1601-1603, 1960.

An experiment for investigation of seismic wave propagation in a low velocity wave guide is described and its results discussed. The changes in velocity and absorption of elastic waves and the wave processes in the wave guide were studied with a wave guide model in the form of a sheet 740X520X5 mm made of paraffin-polyethylene alloy (97:3), which changes its elastic properties with change of temperature. A wire that could be heated by electric current was embedded in the plate. The radiant heat from the wire affected the elasticity of the plate, forming a low velocity channel with diffuse boundaries. The velocity and amplitude curves in terms of changing temperature, the curves of the energy capture, and the form of the wave guide layer were obtained. — A. J. S.

186-273. Bayuk, Ye. I. Izucheniye uprugikh svoystv obraztsov gornykh porod iz glubokoy skvazhiny pri vysokikh davleniyakh [Study of elastic properties of rock samples from a deep borehole under high pressures]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1756-1761, 1960.

Cores of sedimentary rocks were tested for elastic parameters. The first tests were made under atmospheric pressure and showed that in general the density and the values of elastic properties of the rocks increase and porosity decreases with depth. The three deepest samples deviate from this regularity, however. Subsequent tests were conducted under confining pressure increased in steps of 200-300, 500, and 1,000 kg per cm^2 . The elastic parameters of the rocks increase with increased pressure. The rate of the increase is especially pronounced up to a pressure of 1,000 kg per cm^2 , depending also on the depth from which the samples tested were taken. The values of V_p , V_s , σ , G , and E are given in terms of the composition of the core and the pressure applied. — A. J. S.

186-274. Rapoport, M. B. Ob otrazhenii seysmicheskikh voln ot nezerkal'nykh granits [On reflection of seismic waves from nonspecular boundaries]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 185-196, 1961.

The structure of the wave field of a nonstationary (quasi-sinusoidal) wave emitted by a point source and reflected from a nonspecular boundary is discussed. Secondary diffracted waves that are generated under certain conditions and travel with a dispersion of the phase velocity along the profile possess specific properties which explain many phenomena observed in prospecting by the method of controlled oriented reception of seismic waves (RNP method). Experiments on models of periodically rough boundaries and the secondary diffracted waves isolated in the laboratory by the RNP method are found to agree with the theoretical findings. — A. J. S.

186-275. Rykunov, L. N., and Feofilaktov, V. D. P'yezoelektricheskiy izluchatel' ul'trazvukovykh impul'sov tipa odinochnogo vybrosa dlya modelirovaniya seysmicheskikh voln [Piezoelectric emitter of ultrasonic impulses of single ejection type for modeling of seismic waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 205-214, 1961.

Free vibrations excited in a pack of 45° Z-cut ammonium dihydrogen phosphate plates by electric pulses are made up of two superimposed modes on

different frequencies that cause different kinds of deformation of the plates. The characteristics of these deformations make it possible to eliminate one of the modes so as to produce an oscillator characterized by one natural frequency. The vibrations excited in this oscillator by square electric pulses of varying duration were examined, and on this basis an emitter was designed to radiate elastic ultrasonic pulses of various forms and, in particular, a single-ejection type. — Authors' abstract, J. W. C.

- 186-276. Ulomov, V. I. O modelirovanii ochagov tektonicheskikh zemletryaseniy pri pomoshchi ul'trazvukovykh izluchateley [On modeling of foci of tectonic earthquakes with the aid of ultrasonic emitters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 255-248, 1961.

A piezoelectric emitter of elastic waves having a distribution of forces equivalent to the distribution of forces at a real focus of an earthquake is described. The stresses arising in a fault earthquake are compared with the stresses in a paraffin model subjected to narrow rectangular electric impulses transformed into mechanical impulses of a desired width. Diagrams of sign and intensity distribution of the first arrival around the emitter are given for a vertical fault and for a vertical rupture in the model. — A. J. S.

- 186-277. Rykunov, L. N., and Selyuminov, S. D. Generator impul'sov dlya vozbuzhdeniya p'yezoelektricheskikh izluchateley [An impulse generator for excitation of piezoelectric emitters]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 730-731, 1961.

Construction and operation of a piezoelectrical electronic generator of trapezoidal impulses having a minimum of residual oscillation is discussed. The generator consists of a blocking generator, a cathode repeater, and an output amplifier. The residual oscillations emitted by a 2-cm cube of ammonium dihydrophosphate excited by the generator described were found to be 7 percent or less. A circuit diagram and oscillograms of the device are given. — A. J. S.

- 186-278. Frolov, A. D. Rasprostraneniye ul'trazvuka v merzlykh peschanoglinistyykh porodakh [Propagation of ultrasound in frozen sandy-clayey rocks]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 732-736, 1961.

An experimental study was made of ultrasonic velocities in 116 specimens of clay, 56 specimens of interbedded clay and sand, 45 specimens of sand, and 14 specimens of sandstone at temperatures of -20° , -10° , -5° , -2° , -0° , $+2^{\circ}$, and $+20^{\circ}\text{C}$. The results are tabulated and also presented in graphs. — J. W. C.

- 186-279. Adachi, Ryuzo. On the magnification of the record of a vibration by an electromagnetic-type transducer and a galvanometer [in Japanese with English abstract]: Butsuri-Tankō, v. 13, no. 2, p. 96-101, 1960.

The mathematical expressions for the magnification of the displacement, velocity, and acceleration of a vibration by an electromagnetic-type transducer and a galvanometer are given. The method of determining the values of the damping coefficients is discussed, and the results are illustrated. — V. S. N.

- 186-280. Kutschale, Henry. Long-range sound transmission in the Arctic Ocean: Jour. Geophys. Research, v. 66, no. 7, p. 2189-2198, 1961.

Strong hydroacoustic signals from underwater explosions as small as 2 lb of TNT have been detected in the Arctic Ocean at distances up to 1,150 km by hydrophones at depth and geophones on the ice surface. The signals propagate in the Sofar channel, but the character of the signals differs markedly from that typical of the nonpolar regions largely because of the predominance of low-frequency waves in the Arctic. The character of these signals is best explained by normal-mode wave propagation in a channel bounded by the surface and by the zone of increasing velocity in the upper several hundred meters of water. Irregularities in the ice boundaries apparently strongly attenuate the high-frequency waves but have a negligible effect on the amplitudes of the low-frequency waves. At least 2 normal modes were observed; in each, the waves have a nearly sinusoidal appearance with periods decreasing from about 120 to 30 msec in the first mode and from 70 to 40 msec in the second mode. A good quantitative fit between experimental data and theoretical dispersion curves has been obtained. The signals were detected in both deep and shallow water. — D. B. V.

- 186-281. Hudson, D[onald] E[llis], Alford, J. L., and Iwan, W. D. Ground accelerations caused by large quarry blasts: *Seismol. Soc. America Bull.*, v. 51, no. 2, p. 191-202, 1961.

Ground acceleration-time measurements have been made within 2,000 feet of 2 quarry blasts of total charge weight 185 and 673 tons. The character and magnitude of the ground accelerations were similar to those associated with damaging earthquakes. Complete response spectrum curves calculated from the acceleration records are presented. Direct comparisons are made between these results and previous similar measurements and calculations of strong-motion earthquakes, high explosive blasts, and the Rainier nuclear blast. — D. B. V.

- 186-282. Leet, L[ewis] Don. *Vibrations from blasting rock*: Cambridge, Harvard Univ. Press, 134 p., 1960.

This book, designed primarily for readers with some technical training who have not been active in engineering or research in recent years, brings together all available information on vibrations caused by the detonation of explosives. Such factors are discussed as the characteristics of rock, the preparation of blasts, events during and after detonation, and the nature of explosives. Methods of recording the elastic waves generated in the earth and their significant features, and the criteria for estimating their ability to damage structures are described. The unique features of motion within the potential crater zone and the use of impedance ratios to achieve maximum blasting efficiency are also discussed. — V. S. N.

- Hoffman, John P., Berg, Joseph W., Jr., and Cook, Kenneth L. Discontinuities in the earth's upper mantle as indicated by reflected seismic energy. See *Geophys. Abs.* 186-442.

Steinhart, J. S., and Meyer, R. P. (with contributions by Woollard, G. P., Bonini, W. E., and Smith, T. J.). Explosion studies of continental structure. See *Geophys. Abs.* 186-431.

- 186-283. Pasechnik, I. P. K opredeleniyu parametrov zatukhaniya voln P_n i S^* [On determination of damping parameters of P_n and S^* waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 12, p. 1740-1743, 1960.

An evaluation of the power of the divergence function "n" and the amplitude absorption "α" is made by two independent methods from single amplitude

curves of P_n and S^* waves obtained along a profile from underground nuclear explosions of 5 and 19 kilotons equivalent and also from the Arystrot'yl explosion. Mean values of $n \approx 2$, $\alpha = 0.0022$ per km were found for waves P_n of 0.6-0.8 sec oscillation period, and $n \approx 1.7$, $\alpha = 0.0023$ per km for S^* waves of 1.0-1.2 period. — Author's abstract, A. J. S.

- 186-284. Pasechnik, I. P. Seismicheskiy metod obnaruzheniya i identifikatsii yadernykh vzryvov [Seismic method of detection and identification of nuclear explosions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 835-846, 1961.

Quantitative characteristics of seismic noise level at quiet, medium, and noisy seismic stations for various period ranges are given. The seismic method of detection of elastic waves caused by nuclear and chemical explosions is discussed. The correlation between seismic wave amplitudes and epicentral distances of the explosion points are analyzed. Groups of up to 100 vertical seismographs connected to the same galvanometer, seismographs in deep (up to 2 km) boreholes, and seismographs on the ocean floor are recommended to avoid seismic noises causing more than 20% elastic displacement in the rock. — A. J. S.

- 186-285. Kubotera, Akira, and Okano, Kennosuke. Observations of seismic and microbarometric waves produced by nuclear explosions [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 4, p. 210-218, 1960.

A new type of wave group has been found on the records of long-period seismographs from the nuclear explosions in the central Pacific (Bikini Atoll) in June and July 1958. The wave has a period of 9 to 1 min and a propagation velocity of about 300 m per sec; its arrival time is about 3 hr later than that of the seismic P-wave. The waves are attributed to the effect of atmospheric pressure fluctuations upon the inert mass of the seismograph. — V. S. N.

- 186-286. Iida, Kumizi, and Aoki, Harumi. Attenuation of seismic waves in the vicinity of explosive seismic origin: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 109-119, 1960.

Seismic wave attenuation characteristics in a viscoelastic medium in the vicinity of an explosive origin are investigated by comparison of Fourier components of body waves at various distances from the seismic origin. Results from field experiments show that the attenuation law can be explained approximately by the viscoelasticity of a Voigt type medium. The decrease in amplitude with distance r is found theoretically to be intermediate between $e^{-\alpha r}$ and r^{-n} ; the index of attenuation of the seismic waves in the area of field experiment was found to be 2.22, a value considerably different from that of a perfectly elastic body. The solid viscosity coefficient of the medium in which the seismic waves are propagated is of the order of 10^7 cgs units, and the ratio of the solid viscosity coefficient to the square of the wave velocity is of the order of 10^{-3} . — V. S. N.

- 186-287. Aoki, Harumi. Seismic waves in the region near explosive origin: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 120-173, 1960.

Experimental and theoretical investigations of the shape of seismic waves radiated from an explosive seismic origin and the mechanisms of wave generation are described. It is shown that near the ground surface the nearly spherical waves generated at the point of origin are somewhat affected by the inho-

anogeneity of superficial structures of the medium resulting in a deviation of wave form from spherical symmetry, and the smaller the amount of charge the more is the fluctuation of amplitude. The form and propagation of the elastic waves that proceed ahead of the plastic wave front are discussed also, and it is concluded that the ratio λ/μ and the expansion of the plastic region are important factors in determining the shape of an elastic wave. The observed elastic waves are composed chiefly of free oscillations of the crushed region produced by the detonation of the explosive, although in the solution of the wave equation, the first half-cycle of the disturbance may be represented by forced oscillation terms. However, the experimental results, such as change in amplitude with change in charge size and shape during progression of the disturbance, do not agree with the theoretical results unless the viscoelastic behavior of the medium is taken into account. — V. S. N.

ELECTRICAL EXPLORATION

- 186-288. Wait, James R. A phenomenological theory of induced electrical polarization: Canadian Jour. Physics, v. 36, no. 12, p. 1634-1644, 1958.

A brief theoretical derivation is presented for the effective conductivity and dielectric constant of a homogeneous medium loaded with a uniform distribution of spherical conducting particles. To account for the effect of induced polarization the particles are taken to have a concentric membrane or film which has a blocking action to the current flow into the particle. The characteristics of this phenomenological model are very similar to the experimentally observed features of induced polarization in a block of compacted andesite particles which contains a dissemination of small metal particles and is partially saturated with a weak electrolyte. The theory is then extended to a two-layer medium where the lower region is polarizable. The results explain, at least in a qualitative way, the observed features of induced electrical polarization in rocks, soils, and clay. — Author's abstract

- 186-289. Ward, Stanley H. The electromagnetic response of a magnetic iron ore deposit: Geophys. Prosp., v. 9, no. 2, p. 191-202, 1961.

Field experiments in the vicinity of a tabular body of nearly massive magnetite have demonstrated that the body may respond in either of two ways; it may react as a permeable mass, or it may react as an eddy current indicator, depending upon the frequency employed. If several frequencies, spanning a broad range, are employed, both types of response will be experienced. The transition from one type of response to the other would appear to have considerable significance. Based upon theoretical and empirical work to date, it seems possible to establish a relationship between transition frequency and percentage magnetite at any given section of a deposit. — Author's abstract

- 186-290. Bosschart, R. A. On the occurrence of low resistivity geological conductors: Geophys. Prosp., v. 9, no. 2, p. 203-212, 1961.

On the basis of past field results the possibility has been denied that natural massive sulfide orebodies could have as low resistivities as those measured on laboratory specimens (of the order of 0-10 ohm-cm). This paper discusses anomalies obtained with the loop-frame method on massive sulfide bodies in different parts of Canada. Model experiments show that the conductors all have very low resistivities which, where effective thickness can be determined, appear to correspond to the order of magnitude of the laboratory specimen resistivity. It is demonstrated that confusion of the total width with effective thickness of a conductor may lead to erroneous resistivity data. — D. B. V.

- 186-291. Alfano, Luigi]. The influence of surface formations on the apparent resistivity values in electrical prospecting. Pt. 2: *Geophys. Prosp.*, v. 9, no. 2, p. 213-241, 1961.

In part 1 (see *Geophys. Abs.* 184-279) the theory developed in a previous paper (see *Geophys. Abs.* 179-133) was applied to the problem of surface inhomogeneities with cylindrical structure; this part treats those with noncylindrical structure, taking into account effects due to potential electrodes and to current electrodes. Almost all the conclusions drawn in part 1 are found to be generally valid. Details of the calculation procedure are given to show the suitability of the method used for study of this problem. — D. B. V.

- 186-292. Crea, Antonio. Perturbazione indotta nel campo di un elettrodo rettilineo indefinito da un piano perfettamente conduttore parallelo all'elettrodo [Perturbations induced in the field of a rectilinear indefinite electrode by a perfectly conducting plane parallel to the electrode (with English and German summaries)]: *Geofisica Pura e Appl.*, v. 46, p. 83-94, 1960.

This paper calculates the electrical field and potential generated by a filiform, rectilinear, indefinite electrode on the surface of a homogeneous ground containing, at a given depth, a perfectly conducting plane. In practice, such a plane could be a metalliferous vein having a thickness that is negligible compared to its other dimensions. The contrast between this and the shape of the potential in the case of the same electrode on homogeneous ground is striking. — D. B. V.

- 186-293. Seshadri, S. R. Diffraction of a plane wave by a unidirectionally conducting half-plane: *India Natl. Inst. Sci. Proc.*, v. 27, pt. A, no. 1, p. 1-10, 1961.

The problem of the diffraction of a plane wave by a unidirectionally conducting half-plane is formulated in terms of an integral equation whose solution is obtained by the standard Wiener-Hopf procedure. Expressions for the fields and the current induced on the screen are given. — V. S. N.

- 186-294. Shaub, Yu. B. O primenenií metoda vrashchayushchegosya magnitnogo polya dlya elektrokartirovaniya [On application of the method of the rotating magnetic field for electrical mapping]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 10, p. 1485-1489, 1960.

The correlation between the active and reactive components of a disbalanced signal and the electrical resistivity of a homogeneous half-space (homogeneous earth) is analyzed, with a view toward application to airborne geologic mapping by the method of rotating magnetic field (see *Geophys. Abs.* 162-67, 165-112, 174-117). It was found that by measuring the two orthogonal components of the disbalanced signal the method can be applied advantageously not only to prospecting for highly conducting ore bodies but also to mapping of the country rock. — A. J. S.

- 186-295. Shakhshvarov, D. N., and Rybakova, Ye. V. O primenimosti predstavleniy dal'ney zony pri chastotnykh elektromagnitnykh zondirovaniyakh [On applicability of the distant zone concept in frequency electromagnetic sounding]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 11, p. 1604-1607, 1960.

This is a development of Van'yan's (see *Geophys. Abs.* 180-108) and Tikhonov and Shakhshvarov's (see *Geophys. Abs.* 179-147) papers on the theory of di-

pole electromagnetic field of a distant zone. For the case of a layer of apparent resistivity ρ_1 underlain with a layer of $\rho_2=0$, this method leads to a satisfactory interpretation of the profile investigated by permitting construction of simple master charts. The amplitude and phase characteristics of the electric and magnetic components of the field cannot be determined uniquely when the underlying basement rock is an insulator. Serious errors in the profile determination may occur if the concept of distant zone is applied when ρ_2 differs considerably from zero. — A. J. S.

- 186-296. Glyuzman, A. M. Pole tochechnogo istochnika toka, raspolozhen-nogo na granitse poluprostranstva v prisutstvii paraboloidal'noy poverkhnosti razdela [Field of a point source of a current located on the boundary of a half-space which includes a paraboloid interface]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1791-1795, 1960.

A mathematical analysis is presented for the field that results from an electric current point source situated inside and outside of a paraboloid of revolution, which forms an interface in the lower half-space. Formulas for the potential functions are derived for both cases. — A. J. S.

- 186-297. Dmitriyev, V. I. Ekraniruyushcheye vliyaniye nanosov na anomal'-noye pole [The screening effect of alluvium on an anomalous field]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 46-53, 1961.

A rigorous solution of the diffraction problem of electromagnetic field on a perfectly conducting half-plane immersed in a homogeneous conducting half-space covered with a conducting layer of different resistivity is given. The solution is presented in the form of an absolutely convergent monotonic series, one or two terms of which are sufficient for practically accurate results. — A. J. S.

- 186-298. Tikhonov, A. N., and Shakhshvarov, D. N. O neravnomernosti asimptotiki elektromagnitnykh poley, vzbuzhdayemykh dipolem peremennogo toka v sloistoy srede [On nonuniformity of the asymptotics of electromagnetic fields induced by an a-c dipole in a layered medium]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 107-110, 1961.

This is a further development of the study of electromagnetic fields induced by an a-c dipole in a layered medium (see Geophys. Abs. 179-147) showing that

$$\lim_{r \rightarrow \infty} B_z^* \neq \lim_{r \rightarrow \infty} B_z^*, \quad \text{where } \tilde{B}_z^* = r^2 \tilde{B}_z / \Lambda_1^2$$

$$r \rightarrow \infty \quad \mu_2 \rightarrow \infty \quad r \rightarrow \infty$$

where \tilde{B}_z is a nondimensional complex amplitude which depends on the structure of the medium, the distance r from the dipole to the observation point, and current frequency f ; Λ_1 is the wavelength in the upper layer, and μ_2 is the magnetic permeability of the second layer. — A. J. S.

- 186-299. Shaub, Yu. B. O kolichestvennoy mere informatsii dostavlyaemyoy metodamy aereoel'ektorazvedki [On a quantitative standard for information furnished by airborne electric prospecting methods]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 160-168, 1961.

It is feasible to establish a unique quantitative measuring unit for evaluation of the information obtained by various methods of airborne electrical prospecting. A comparison was made for a conducting spherical body using the methods of induction, infinitely long cable, totaling magnetic field, and measuring the angle of inclination of the polarization plane of the natural alternating magnetic field of the earth. The last method is found to be the most effective in prospecting for good-conducting ore bodies. The method of totaling magnetic field and of infinitely long cable are approximately equal in effectiveness, whereas the induction method is the least effective of the four. — A. J. S.

- 186-300. Glyuzman, A. M. Resheniye krayevoy zadachi dlya giperboloida vrashcheniya v elektrorazvedke [Solution of the boundary problem for a hyperboloid of revolution in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 717-724, 1961.

The problem of the distribution of potential from a point source at the boundary of a half space when hyperboloidal interfaces are present is treated analytically. Solutions of the problem are obtained in the form of real integrals which combine the Legendre function with imaginary sign, and its derivative. The coefficients are found with the Mehler-Fok integral theorem of expansion. The integration of the Laplace equation was carried out in the system of degenerated ellipsoidal coordinates. — A. J. S.

- 186-301. Glyuzman, A. M. Resheniye krayevoy zadachi dlya konicheskoy oblasti v elektrorazvedke [Solution of a boundary problem for a conical region in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1009-1015, 1961.

The solution is worked out for the potential distribution problem in electrical prospecting when the distribution in a nonhomogeneous medium bounded by the surface of an infinite circular cone is sought. Formulas are derived for potential distribution along the cone axis lying on the surface plane of the earth, and in a profile that coincides with the cone axis near a hole in the form of a circular cone. — A. J. S.

- 186-302. Tarkhov, A. G. Geofizicheskiye poiski rudnykh mestorozhdeniy [Geophysical prospecting of ore deposits]: Sovetskaya Geologiya, no. 2, p. 108-124, 1961.

Geophysics has not met the growing needs of ore exploration although much progress has been achieved. The depth of exploration can be increased by suppressing the heterogeneities of a field that obscures the geophysical anomaly produced by an ore deposit. This requires certain alterations of present practices. In using the isoline method it would be expedient to eliminate those observations taken in the zone of the electrodes, to increase the unit areas from 1x1 to 2x2 km or even 4x4 km, and to plot changes of the absolute values of potential together with the purely qualitative tracing of the isonomies. Great attention should be given to electrical surveying using alternating current; this includes the method of the ungrounded loop using low frequencies and the induction and radiomethods using high frequencies. The radio-wave method is particularly promising for underground exploration. This method has already yielded good results in study of veinlet-disseminated ores, which are practically inaccessible to direct current surveys. — J. W. C.

Kolmakov, M. V., and Vladimirov, N. P. On the problem of equivalence of magnetotelluric sounding curves. See Geophys. Abs. 186-121.

- 186-303. Yoshizumi, Eizaburo, and Irie, Tsuneji. A new interpretation method of resistivity method—input resistance method [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 2, p. 81-88, 1960.

Resistance network analogs, based on recognition of the formal similarity between Kirchhoff's law equations and the results of finite difference expansion of Laplace's equation, are applied to the solution of data from electrical prospecting. The equivalent resistance network of the two-electrode resistivity method is explained according to potential bowl theory, and a new interpretation method called the input resistance method is proposed. — V. S. N.

- 186-304. Fukuzawa, Hiroshi, and Arima, Sumiteru. Model experiments on the artificial electric potential methods utilizing drill holes and adits [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 3, p. 172-179, 1960.

Model experiments on the electric potential method of prospecting for ore bodies are discussed. The devices used in the experiments, the arrangement of electrodes and model ore body, and the results of the experiments are well illustrated in pictures and graphs. — V. S. N.

- 186-305. Corbett, J. D. An empirical demonstration of geophysical methods across the Caribou deposit, Bathurst, N. B.: Canadian Mining Metall. Bull., v. 54, no. 587, p. 227-229, 1961; Canadian Inst. Mining Metallurgy Trans., v. 64, p. 160-162, 1961.

Profiles are presented of the anomalies over the Caribou massive sulfide deposit, Bathurst, N. B., obtained with six electrical and electromagnetic geophysical techniques. A generalized geologic section is included for correlation purposes. The data are compared empirically, but no attempt is made to compare directly the relative advantages of one method over another. When related to the initial phase of an exploration program, the magnitudes and ratios obtained from any of the methods described would be sufficient to warrant further investigation. — V. S. N.

- 186-306. Fleming, H. W. The Murray deposit, Restigouche County, N. B. — A geochemical-geophysical discovery: Canadian Mining Metall. Bull., v. 54, no. 587, p. 230-235, 1961; Canadian Inst. Mining Metallurgy Trans., v. 64, p. 163-168, 1961.

Eighteen months of coordinated geophysical and geochemical exploration were needed to locate the Murray massive-sulfide deposit in northern New Brunswick. Extensive leaching had produced a fossil gossan that made the deposit an elusive target for exploration techniques of limited penetration. Initial selection of the area was based on anomalies from an airborne electromagnetic survey. The actual target area was localized by geochemical means, but geophysical surveys were necessary to determine the nature of the deposit and to indicate the most favorable drilling sites. Electromagnetic and magnetic data were interpreted to indicate a good nonmagnetic conductor, and it was correctly predicted that massive pyrite would be encountered in drilling. All electrical methods—the horizontal-loop, Turam electromagnetic, and self-potential surveys—indicated the deposits strongly and accurately. — V. S. N.

- 186-307. Artamonov, L. V., and Shuval-Sergeyev, N. M. O primenenií aroelektrozvedki v tselyakh geologicheskogo kartirovaniya [Use of aroelectrical exploration for geologic mapping]: Sovetskaya Geologiya, no. 2, p. 125-132, 1961.

The results are presented of experimental use of **aeroelectrical surveying** during 1959 in the Dzhezkazgan area region of Kazakh S.S.R. These tests were part of a large program to evaluate the method of dipole magnetic **profiling** under a variety of geologic conditions. In the Dzhezkazgan area this method was used successfully to trace contacts of Paleozoic and Cenozoic **deposits**. On the basis of this survey, areas were selected for immediate **prospecting** for copper mineralization. — J. W. C.

- 186-308. Shansi Provincial Department of Agricultural Construction. **Applications of electro-prospecting in hydrogeology and engineering geology work** [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 4, p. 3-6, 1960; translated by U.S. Joint Publications Research Service, JPRS no. 9356, 1961.

The application of electrical prospecting methods to the determination of underground structures and to prospecting for water supply is discussed. Examples are given of the use of the resistivity method in five different localities to locate aquifers, fault planes for engineering construction purposes, and other structures. The electric-charge method for tracing the speed and direction of flow of ground water is also discussed. In this method salt is placed in a borehole or well to decrease the resistivity of the ground water and thus form a highly conductive zone which moves as the ground water moves. — V. S. N.

- 186-309. Hattori, Yasuzo; Mashiko, Yasushi; Sato, Koji, Kanroji, Yasuo; and Hosaya, Noboru. **Geochemical studies on mineral springs, Pt. 9. On the hot springs in Kamigano-Village, Izu** [in Japanese with English abstract]: Balneol. Soc. Japan Jour., v. 12, no. 1, p. 21-22, 1961.

The results of chemical studies of the waters and electrical prospecting in the vicinity of the hot springs in Kamigano, Izu, Japan, are reported. The hot spring water produces a negative anomaly zone near Tsukigase and Sagasawa. In the Nishibira district a positive anomaly occurs over silicified tuff breccia and a negative anomaly over argillized tuff breccia. It is concluded that the natural electric potential anomalies are the result of difficulties in the flow of the hot water. — V. S. N.

- 186-310. Kunori, Shoichi, and Ishii, Fujio. **Studies on the relation between spontaneous polarization potential and mineralization on the adit in the Kaimei mine, Aomori Prefecture** [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 2, p. 118-121, 1960.

The Kaimei mine is an epithermal fissure-filling copper deposit. Twenty-five samples were collected in an interval of 10 m from the propylite host rock and the base exchange capacity was determined to aid in evaluation of results from a spontaneous potential survey. Results of spontaneous potential measurements are discussed in relation to the iron-magnesium chlorite mineralization and a statistical analysis is made. It is concluded that the spontaneous potential values are closely related to the bonanza and also to the increase of exchangeable magnesium ion in the propylites formed before ore deposition. — V. S. N.

- 186-311. Atkins, E. R., Jr. Techniques of electric log interpretation: Jour. Petroleum Technology, v. 13, no. 2, p. 118-124, 1961.

The following techniques of electrical logging are reviewed and discussed: formation water resistivity from SP curves, true resistivity values from log data, water saturation from electric logs, and formation porosity from resistivity data. Particular emphasis is placed on 12 assumptions made in log interpretation. — J. W. C.

- 186-312. Street, Norman. Electrokinetics, III. —Surface conductance and the conductive solid effect: Illinois State Geol. Survey Circ. 315, 16 p., 1961.

Interpretation of electric logs is made difficult by the presence of conductive solids in a formation; therefore, it is desirable that the mechanism of the conduction be fully understood. This discussion concerns the theory and measurement of surface conductance, the condition that is mainly responsible for the conductive solids effect. The application of the theory to logging problems in the petroleum industry is indicated. — V. S. N.

- 186-313. Lum, Daniel. The resistivity method applied to ground water studies of glacial outwash deposits in eastern South Dakota: South Dakota State Geol. Survey Rept. Inv., no. 89, 44 p., 1961.

The results of electrical resistivity surveys of water-bearing glacial outwash deposits of sand and gravel in eastern South Dakota during the summers of 1957 and 1958 are reported. The principles, field procedures, and methods of interpretation are discussed, particularly for the Wenner configuration. The deposits are too inhomogeneous and variable in lithology to permit correlation and interpretation of the resistivity data except for very local and detailed investigations. The horizontal traverse method was found to be more useful than the depth-profile method in locating sites for test wells. Apparent resistivity field curves plotted with theoretical curve-matching interpretations and drill-hole control data from glacial deposits are presented for reference. — V. S. N.

- 186-314. Plewa, Stanisław. Zagadnienie identyfikacji i korelacji pokładów węglowych metodami geofizyki kopalnianej [Problems of identification and correlation of coal seams by means of mining geophysics methods (with English and Russian summaries)]: Przegląd Geol., v. 8, no. 12, p. 640-645, 1960.

The principles of geophysical logging of boreholes in coal seams are discussed. Coal seams can often be distinguished on the resistivity log and on the natural gamma radiation log. The Ruda beds are an example of this; they contain a geophysical marker horizon. In general, geophysical correlation and identification of coal seams is more accurate than geological. Several examples of geophysical correlation are given. — J. W. C.

- 186-315. Sarkisov, I. K., and Makhmudova, V. M. K voprosy teorii elektricheskogo karotazha neftnykh i gazovykh skvazhin [Problem of the theory of electrical logging of oil and gas wells]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 8, p. 17-26, 1960.

Study of the field of linear electrodes is increasingly important in connection with logging boreholes during drilling using the drill pipe as an electrical connector. With linear electrodes of small length, the resistivity of the electrode is negligible; however, where the casing of the cable or the drill pipe is

used as a second electrode, and particularly where the latter is used as an electrical connector, the effect of the resistivity becomes determinable. Diagrams are presented of the configuration of the equipotential lines of the field of electrodes with various lengths and resistivities. These lines change from ellipsoidal to more circular with increasing values of kL , where L = length of the electrode and $k = \sqrt{\rho_0 g_0}$ (ρ_0 is resistivity of a unit length of electrode and g_0 is conductivity of a unit length of electrode). — J. W. C.

- 186-316. Klyucharev, V. S., Shevkunov, Ye. N., and Lazarev, V. N. Izucheniyе karbonatnykh porod po geofizicheskim dannym [Study of carbonate rocks according to geophysical data]: Vyssh. Ucheb. Zavedeniy Izv., Neft' i Gaz, no. 12, p. 15-19, 1960.

Results are presented of experiments in locating marker horizons as well as porous and permeable zones in carbonate rocks of Carboniferous age in the Or'yebash oil field in northwestern Bashkir A.S.S.R. Electrical logs are presented that show how several marker horizons are correlated. Using gamma and neutron gamma logs, empirical relationships were established for determining porous zones. Correlation of the porous zones and shale beds is shown in a profile. — J. W. C.

- 186-317. Zaporozhets, V. M. K voprosu ob oboznachaniyakh velichin ispol'zuyemykh v promyslovoy geofizike [On the problem of symbols of quantities used in logging geophysics]: Prikladnaya Geofizika, no. 27, p. 236-244, 1960.

An attempt is made to establish more regular terminology and symbols than are presently used in logging geophysics of the U. S. S. R. A comparison is made between terms and symbols used in the U. S. S. R. and in the United States. — A. J. S.

- 186-318. Grechukhin, V. V. Korrelyatsiya razrezov uglenosnykh otlozheniy po karotazhnym diagramam [Correlation of sections of coal-bearing deposits by logging diagrams]: Razvedka i Okhrana Nedr, no. 11, p. 28-33, 1960.

Electrical exploration by the method of apparent resistivity for coal deposits in the Pechora basin in the northern Urals is discussed. A standard electric gradient sonde A3, 5MO, 1N was used in borehole logging for a unique determination of coal layers at three separate locations in the Vorkuta region, and the geologic structure of the region was determined by correlation of the layers. A subsurface fault with a displacement of 144 m was discovered by the correlation of electric logging diagrams. — A. J. S.

- 186-319. Ushakov, A. P., and Itenberg, S. S. Opyt ispol'zovaniya geologicheskikh i geofizicheskikh dannykh dlya izucheniya geologii Apsheronского полуострова, vostochnogo i tsentral'nogo Predkavkaz'ya [Experiments in the use of geological and geophysical data for study of the geology of the Apsheron Peninsula, eastern and central Ciscaucasus]: Moskva, Gosudarstvennyy Nauchno-Tekhnicheskii Komitet, 131 p., 1960.

The second half of this work deals with stratigraphic correlation using geophysical logging data. The topics discussed are the geological-geophysical characteristics of the section of a borehole, construction of detailed correlation charts for local structures, type and standard geological-geophysical

sections, and construction of regional correlation charts. An example is presented of how such correlation was accomplished in the east and central Ciscaucasus. — J. W. C.

- 186-320. Ito, Junji. On the prospecting and handy electric-logging at the Makimine mine [in Japanese with English abstract]: *Mining Geology* [Japan], v. 11, no. 45/46, p. 369-372, 1961.

A highly effective micrologging device developed for use in prospecting the bedded cupriferous iron sulfide ores of the Makimine Mine, Miyazaki Prefecture, Japan, is described. With the use of the micrologger the lenticular ore bodies can be prospected from drill holes. — V. S. N.

ELECTRICAL PROPERTIES

- 186-321. Logan, John. Estimation of electrical conductivity from chemical analyses of natural waters: *Jour. Geophys. Research*, v. 66, no. 8, p. 2479-2483, 1961.

Several methods of estimating the electrical conductivity of natural waters from their chemical analyses are tested statistically with a previously undescribed empirical method. Standard errors of estimate resulting from the latter are less than 7 percent for each of two tests; this value is in the range of sampling and analytical error in many cases. — Author's abstract

- 186-322. Howell, B[enjamin] F., Jr., and Licastro, P. H. Dielectric behavior of rocks and minerals: *Am. Mineralogist*, v. 46, no. 3-4, p. 269-288, 1961.

A reconnaissance study of the dielectric constants of 23 common mineral and 71 rock samples was made at 13 frequencies in the range 50c to 30 Mc. Dispersion was observed for all rock samples tested and for a few minerals at the lower end of the frequency spectrum. Moisture in a rock can increase the dielectric constant by an amount greater than is predicted by simple mixing rules. Water appears to be the principal constituent of the rock controlling the dispersion. The observed dispersion was similar in form to the Maxwell-Wagner type polarization, but was quantitatively much greater. Some form of electrode or membrane polarization appears to be the most likely explanation. The dispersion is probably the result of the same mineral properties on which induced-polarization methods of geophysical prospecting are based. — Authors' abstract

- 186-323. Stacey, F. D. Dielectric anisotropy and fabric of rocks: *Geofisica Pura e Appl.*, v. 48, p. 40-48, 1961.

Measurements were made of the dielectric anisotropies of a number of rocks for which magnetic anisotropy data were available in order to examine the possible usefulness of dielectric anisotropy as a physical property indicative of rock fabrics. The advantage over the magnetic method is that dielectric anisotropy reflects the average alinement of crystals of dominant minerals, whereas magnetic anisotropy is due only to the ferromagnetic grains. Disadvantages are extreme sensitivity to specimen shape and difficulty in distinguishing the several types of alinement that can give rise to dielectric anisotropy.

The results indicate that dielectric anisotropy actually is a measurable property of rocks and can be used in petrofabric work. It should be very

suitable for detailed examination of the problem of crystal settling. Suggestions are made concerning improvements over the method used here. — D. B. V.

- 186-324. Migaux, Léon, Astier, Jean-Louis, and Revol, Philippe. Essai de détermination expérimentale de la résistivité électrique des couches profondes de l'écorce terrestre [Attempt at experimental determination of the electrical resistivity of the deep layers of the earth's crust]: Acad. Sci. [Paris] Comptes Rendus, v. 251, no. 4, p. 567-569, 1960.

D-c electrical resistivity soundings, using a conventional four-electrode setup, were carried out in the homogeneous Mortagne granitic massif in the Vendée, France. The experimental results, presented in a curve compared to a theoretical curve, indicate that average apparent resistivity is 200 ohm-m to 10 m depth, 250 ohm-m to 580 m, and 1,400 ohm-m to 7,000 m. At about 7,000 m it begins to increase sharply; eventually true resistivity (ρ) must reach at least 15,000 ohm-m before decreasing due to the presence of a good conducting medium below.

The thickness (e) of the resistant layer is such that $e\rho > 250$ megohms per m^2 (probably about 400 and not more than 1,000 megohms per m^2); the mean resistivity value would correspond, for instance, to a 25 km layer averaging 16,000 ohm-m or an 8-km layer averaging 50,000 ohm-m. These high resistivities at depth are explained by the fact that any increase in conductivity due to increase in temperature is largely compensated by a diminution in the amount of electrolyte in the rocks. — D. B. V.

- 186-325. Volarovich, M. P., Tarasov, O. A., and Bondarenko, A. T. Issledovaniye dielektricheskoy pronitsayemosti obraztsov gornykh porod pri atmosfernom odnostoronnnem u vsestoronnnem (do 5,000 kg/cm^2) davleniyakh [Investigation of dielectric permeability of rock samples under unilateral atmospheric pressure, and confining (up to 5,000 kg/cm^2) pressure]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1004-1008, 1961.

The methods of determination of electric permeability (dielectric constant) ϵ of rock samples under varying pressure at a frequency of 500 kc are discussed. Dielectric constants of sandstone, limestone, syenite, granite, and diabase were determined under unilateral pressure; the greatest change in the value of ϵ was found to be in the pressure range up to 600 kg/cm^2 . Under confining pressures up to 5,000 kg/cm^2 , ϵ of the rocks increased by 10-30 percent. The increase in ϵ of rocks under pressure was found to be due mainly to a decrease in the volume of pores, an increase in the contact area of the structural elements of the minerals, and the subsequent increase in the number of polarized particles per unit volume. — A. J. S.

- 186-326. Berlin, T. S., and Khabakov, A. V. O razlichniyakh elektrokineticheskikh potentsialov karbonatnykh osadochnykh gornykh porod razlichnogo genezisa i sostava [On differences in the electrokinetic potentials of carbonate sediments of different origin and composition (with English summary)]: Geokhimiya, no. 3, p. 195-208, 1961.

Investigation of 115 samples of different sedimentary carbonate rocks shows that those that originated by chemical precipitation have a positive and those of organic origin a negative electrokinetic potential (ζ). The effect of various impurities on the sign and magnitude of the ζ -potential is discussed. — D. B. V.

- 186-327. Newfarmer, L. R. Geophysics' share of the exploration dollar in the U. S. A. and Canada: Oil in Canada, v. 13, no. 32, p. 33-35, 1961.

In 1952, a high point in geophysical field work, 40,456 party weeks of reflection seismograph work were completed on the North American continent; by 1959 this number had fallen to 24,321 party weeks. However, as nearly two-thirds of the continent's six million cubic miles of sediments remain to be explored in detail, a leveling-off in this downward trend is to be expected. — V. S. N.

- 186-328. Oilweek. Crisis in geophysics: Oilweek, v. 12, no. 26, p. 20-24, 1960.

An eight-year decline in geophysical exploration activity in Canada is leveling off. Most observers predict a two to five year level period before activity gains appreciably. One of the great difficulties in Canada is the highly seasonal nature of the operations resulting from the trend to northern areas in the past five years. It is probable that contracting companies will have to pay a premium for work in the winter when crews are scarce, or else spread the work more evenly throughout the year. — V. S. N.

- 186-329. Garlick, W. G., and Gane, P. G. Geophysics, in The geology of the Northern Rhodesian Copperbelt: London, Macdonald and Co., Ltd., p. 178-187, 1961.

An appraisal is given of the prospecting value of various geophysical methods in the Copperbelt, Northern Rhodesia. The deep residual soils with a laterite zone of variable thickness grading down into weathered formations and the generally complete oxidation of sulfides to a depth of 200 feet constitute a severe handicap to most geophysical methods. Electrical, magnetic, and gravimetric methods have been used, and most have been unsuccessful as direct indicators of sulfide bodies; the self-potential method has been of use in direct indication of oxidizing sulfides—more commonly pyrite than copper sulfides. All of the geophysical methods that are not too expensive to operate have considerable value in recognition of the various characteristics of hidden rock formations and thus are used indirectly to locate mineralization. Geochemical methods have been highly effective in direct exploration for mineralization. However, those orebodies which fail to reach into the zone of weathering are unlikely to show any appreciable surface geochemical anomaly and must be discovered by drillholes located on the basis of thorough knowledge of the geology and on data provided by geophysical methods capable of indicating the deep sulfide bodies directly. Continued refinement of instruments and methods may make geophysical methods as useful as geochemical in the Copperbelt. A brief history of the use of geophysical methods is given, and the individual methods tested are discussed. Seismic methods have not been used because of the high cost in this area. — V. S. N.

- 186-330. Vol'fson, N. B., Gar'kovets, V. G., and Khvalovskiy, A. G. Opyt primeneniya geofizicheskikh metodov pri reshenii nekotorykh voprosov glubinnogo geologicheskogo kartirovaniya v Almalykskom rudnom rayone [Experience in the use of geophysical methods for solving several problems of subsurface geological mapping in the Almalyk ore region]: Sovetskaya Geologiya, no. 1, p. 109-120, 1961.

As a result of combined magnetic and geological surveys in the Almalyk ore region of the Uzbek S. S. R., areas of altered and unaltered syenite were

distinguished, and the position of a deep-seated granodiorite porphyry and its stockwork of apophyses was determined. A spatial association of copper and lead mineralization with the granodiorite porphyry was established, and a horizontal zonality in the distribution of the ore was revealed. The thickness of an effusive cover was determined by vertical electrical sounding. — J. W.C.

- 186-331. Sato, Konosuke. Recent development in geophysical exploration [in Japanese with English abstract]: *Mining Geology [Japan]*, v. 11, no. 45/46, p. 365-369, 1961.

Newly developed Japanese techniques in geophysical surveying methods for oil; coal; radioactive, metallic, and nonmetallic minerals; ground water; natural steam; and in civil engineering problems are described. Future problems in geophysical exploration in Japan are discussed. — V. S. N.

- 186-332. Lister, H. Is Antarctica a continent?, in *Science Survey 1: New York*, MacMillan Co., p. 257-266, 1960.

A popular account is given of the scientific evidence on the nature of the continent underlying the Antarctic icecap. Recent studies, started during the International Geophysical Year, have contributed the greater part of the information. Results so far achieved, although meagre, all point to Antarctica being a continent. — V. S. N.

- 186-333. Hoinkes, H. Die Antarktis und die geophysikalische Erforschung der Erde [The Antarctic and the geophysical investigation of the earth]: *Naturwissenschaften*, v. 48, no. 9, p. 354-374, 1961.

This is a review of geophysical research in the Antarctic, mainly during the International Geophysical Year. The present ice cap and subglacial topography, the present mass budget of the ice, and sea level fluctuations related to the Antarctic ice budget are discussed. A 110-item bibliography is given. — D. B. V.

- 186-334. Hatherton, T. New Zealand IGY Antarctic expeditions, Scott Base and Hallett Station: *New Zealand Dept. Sci. Indus. Research Bull.*, no. 140, 132 p., 1961.

The work contributed by New Zealand's Antarctic expeditions at Scott Base and Hallett Station to the International Geophysical Year in 1957 and 1958 is reviewed briefly. The location, design, and construction of the bases are described, and a summary of the results of the scientific investigations in meteorology, geomagnetism, auroras, vertical ionospheric soundings, glaciology, oceanography, seismology, gravity, and whistlers is given. — V. S. N.

GENERAL

- 186-335. Fultz, Dave. Developments in controlled experiments on larger scale geophysical problems, in *Advances in Geophysics*, v. 7: New York and London, Academic Press, p. 1-103, 1961.

A review is presented of experimental developments mainly in meteorology and oceanography but also including work in geology and certain other fields. Emphasis is placed on experiments that have begun to be quantitatively successful in the realm of medium- and large-scale phenomena. The topics touched upon are approached from the point of view of macroscopic continuum mechanics; the tacit hypothesis being that some form of the equations of hy-

drodynamics, thermodynamics, or elasticity governs the phenomena in question. Under large-scale natural phenomena are discussed experimental meteorological and oceanographic work involving properties of homogeneous fluids, density differences, and convection; geological work on the elastic and plastic behavior of the earth; and work connected with cosmic electromagnetic phenomena such as the aurora. Under medium-scale phenomena three groups of investigations are surveyed. The first two involve almost purely hydrodynamic effects of density fields under the influence of gravity for primarily vertically stable density distributions and for essentially unstable arrangements; the third concerns the problems of elastic wave propagation relevant to seismic waves either artificial or natural. — V. S. N.

- 186-336. Krauskopf, Konrad, and Beiser, Arthur. *The physical Universe*: New York, McGraw-Hill Book Co., Inc., 536 p., 1960.

The aim of this textbook is to present the essential elements of physical science to the reader who has a minimum of formal preparation. Basic concepts and their role in understanding the natural world are emphasized, and an effort is made to convey something of the historical and philosophical development of physical science. Topics that currently lie on the frontier of knowledge—elementary particles, cosmic rays, thermonuclear power, DNA and RNA, and the origin of the universe—are specifically mentioned. The following chapters are included: the sun and its family; force and motion; gravitation; energy; solids, liquids, and gases; basic chemistry; the periodic table; electricity; currents and magnetic fields; light; the atomic nucleus; atomic structure; subatomic chemistry; fundamentals of chemistry; organic chemistry; rocks and minerals; the changing crust; the atmosphere; within the earth; the history of the earth; the sun; structure of the universe and evolution of the universe. Two types of exercises for each chapter are provided in the appendix. One or more references for further reading are given at the end of each chapter. — V. S. N.

- 186-337. True, Webster P., ed. *Smithsonian Treasury of science*, v. 1: New York, Simon and Schuster, Inc. 377 p., 1960.

The 17 papers included in this volume are reprinted from various Annual Reports of the Smithsonian Institution; in some cases the papers were originally published in scientific journals. For the more recent articles, the authors have made such minor revisions as seemed desirable to indicate current changes in thought. Most of the articles, however, have been chosen for their more or less timeless character. The following papers of particular interest to geophysics are included in this first volume: Claude W. Heaps—The structure of the universe; E. J. Öpik—The time scale of our universe; Thornton Page—The origin of the earth; John W. Evans—Solar influence on the earth; Fred L. Whipple—Meteoroids; Paul C. Aebersold—Radioisotopes; and Hans E. Suess—The abundance of the chemical elements. — V. S. N.

- 186-338. Fairbridge, Rhodes W. *Eustatic changes in sea level*, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 99-185, 1961.

A study of basic data associated with eustatic changes in sea level is presented. Historical and contemporary observations are reviewed; theories of shoreline displacements and the development of an integrated theory are discussed; and Quaternary changes in sea level are analyzed. Pleistocene eustatic curves given in this paper show that there are overriding controls of eustasy that supersede both climatic and local tectonic influences. Eustatic

changes are now recognized universally, and a basic assumption of possible eustatic events should be made for every geologic period regardless of climatic events. During the Quaternary, two major and several minor effects are noticeable: (1) a climatically controlled glacio-eustasy involving vertical oscillations of a few meters up to 100 or 125 m in periods from 550 to 90,000 yr; (2) a geodetic effect, associated with the shape of the geoid in respect to the spheroid, and perhaps associated with a polar shift—this is probably tectono-eustatic in part; and (3) the minor roles of glacial loading and unbalancing effects on the globe that have not yet been analyzed. A close correlation is observable over the last 15,000 yr between minor oscillations of sea level and climatic events; geomorphic and stratigraphic effects can be recognized also. In general, the study results in implications that impinge on the fields of meteorology, geodesy, tectonophysics, and stratigraphy, and that urgently call for intensive quantitative investigation. A bibliography of approximately 350 references is included. — V. S. N.

- 186-339. Fairbridge, Rhodes W. The changing level of the sea: *Sci. American*, v. 202, no. 5, p. 70-79, 1960.

Glacial cycles and the slow sinking of the ocean floor or rise of continents have caused sea level to fluctuate from epoch to epoch. The slow changes caused by crustal movements are either reinforced or obscured by the more rapid changes caused by the melting of glaciers. The history of the Quaternary ice age leads to one dominant conclusion: Sea level is a most variable plane and a sensitive indicator of even minor world climatic change. Since the geoid corresponds to sea level at any given time, it must vary with the cycle of world climate. Thus the geoid fluctuates around three norms: a stage of minimum dimension when vast ice sheets cover much of the earth in the brief glacial stages; a stage of maximum dimension when the earth is relatively free of ice; and a stage of oscillation between these extremes in interglacial periods such as the present when a large portion of the earth's water is held in the Greenland and Antarctic icecaps. — V. S. N.

- 186-340. Bascom, Willard. A hole in the bottom of the sea: Garden City, New York, Doubleday and Company, Inc., 352 p., 1961.

The history of geologic thought about the earth is reviewed, and modern methods of making indirect investigations of the earth's interior are described. A discussion is included of the bearing of geology, oceanography, engineering, modern drilling technology, and various other fields on these investigations and of their application to the specific plan for drilling a hole to the M-discontinuity. The following topics are discussed: origin of the Mohole idea, science fiction and pseudoscience inside the earth, evidence in the rocks, exploring the crust with gravity, probing with earthquakes and explosions, the examination of the oceans, magnetism, heat and pressure, evidence in the skies, objectives and sites, modern oil-well drilling, the oil rig goes to sea, experimental holes in deep water, on to the Moho, and the future. An appendix lists unit equivalents, a bibliography, and the membership of the American Miscellaneous Society committee for the Mohole. — V. S. N.

- 186-341. Montandon, Frédéric. Les grandes catastrophes naturelles survenues pendant les années 1948-1957 [The great natural catastrophes happening during the years 1948-1957]: *Rev. Étude Calamités*, no. 36, p. 58-60, 1959.

The great natural disasters (continental inundations, marine invasions, oceanic cyclones and tornadoes, earthquakes, volcanic eruptions, and others)

of the world during the 10 year period 1948-57 are tabulated according to the total number of each type of disaster per year and the total number of each type by country for the entire period. Continental inundations accounted for the largest number of disasters; cyclones and tornadoes were next, followed by earthquakes. — V. S. N.

- 186-342. Chapman, Sydney. From Polar Year to Geophysical Year: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 4, p. 313-324, 1960.

This is the text of a paper presented at a conference held near Prague on March 28-30, 1960, on the contribution of Czechoslovakia to the International Geophysical Year and Cooperation. It is a review of international cooperative efforts in geophysics, the First and Second International Polar Years, and the International Geophysical Year. — D. B. V.

- 186-343. Alger, R. P. Modern logging programs and interpretation methods: Canadian Oil and Gas Industries, v. 14, no. 6, p. 41-58, 1961.

The responses of recently developed logging methods—induction log, laterolog, proximity log, sonic log, and gamma-gamma density log—to varied borehole and formation conditions are now sufficiently understood to permit the proper selection of logs for most efficient interpretation. The new logs are discussed with a brief indication of where each fits into the several families of logging devices and with an outline of the essential logging combinations or programs by mud and formation type. A summary table recapitulates the appropriate usage of tools. Numerous diagrams and tables are included. — V. S. N.

- 186-344. Aswathanarayana, U. Nuclear geology—a review: Indian Minerals, v. 14, no. 4, p. 342-346, 1960.

The four principal facets of nuclear geology—measurement of geological time, radioactive heat generation in the crustal rocks, isotopic abundances and their geological significance, and radiometric surveys—are reviewed briefly. — V. S. N.

- 186-345. Tarkhov, A. G., and Sidorov, A. A. O matematicheskoy obrabotke geofizicheskikh dannykh [On the mathematical treatment of geophysical data]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 10, p. 1450-1457, 1960.

The problem of statistical treatment of geophysical data on the basis of information theory (see Geophys. Abs. 177-165) for the purpose of separating true anomaly data from superposed natural and man-produced interferences is discussed. The arithmetical and geometrical averages and the method of the inverse probability are capable of substantially increasing the anomaly to interference ratio. Methods of statistical filtration of the signal (anomaly) from the noise (interference) background may decrease the absolute value of the signal, but the signal to noise ratio may be increased considerably by statistical suppression of the noise. Klushin (see Geophys. Abs. 178-192) was able to measure a 0.5 mgal gravity anomaly on a background of interference ranging up to 1.0 mgal by increasing the anomaly to error ratio by 4.1 times. — A. J. S.

GEODESY

- 186-346. Marussi, Antonio. Intrinsic coordinates in practical geodesy: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 83-89, 1961.

The basic concepts of intrinsic geodesy—the local description of the gravity field of the earth using only coordinates and quantities that are physically real and therefore observable—are reviewed. It is shown how the integrability conditions necessary for the existence of the coordinate surfaces and the fundamental operators may be expressed in terms of the curvature of the field and of gravity. The theory is applied to a classic geodetic problem, the generalized Legendre expansion for the displacement of the potential (dynamic height) along an optical path. — D. B. V.

- 186-347. Bhattacharji, J. C. Comments and some suggestions on Hunter's formula of reduction of observed values of gravity to the earth model for use in Stokes's integral: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 162-170, 1961.

The reduction formula as evolved by Hunter [see Geophys. Abs. 178-202], for reducing the observed values of gravity to the surface of the earth model is discussed and proved to be not quite accurate. The main defect involved appears to be due to his ignoring altogether the gravity effect on account of the sphericity of the earth while dealing with the difference of attraction between actual and model earths.

The corrected reduction formula posing again a delicate problem for geodesists, a suggestion is here made for a more convenient method of reduction based on a suitable isostatic hypothesis for use in the Stokes's integral without any real difficulty. — Author's summary

- 186-348. Kaula, W[illiam] M. Analysis of gravitational and geometric aspects of geodetic utilization of satellites: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 104-133, 1961.

Expressions are derived for the first-order effects of any period of any term, U_1^n , of the gravitational potential on the orbital elements, plus the second-order effects arising from the interaction of U_1^n with U_2^0 , the oblateness. The order of magnitude of some daily and semidaily variations is estimated to be ± 100 m from statistical data on the gravitational harmonics.

A general geometric and statistical treatment of all types of observations is developed, with the purposes of obtaining rigorous evaluations of orbital and observational schemes, and optimum solutions for geodetic positions, gravitational harmonic coefficients, and orbital elements. — Author's summary

Tengström, Erik. Calculation of the external gravity anomalies and deflections of the vertical at higher elevations by means of Taylor expansions from the geoid. See Geophys. Abs. 186-388.

Ledersteger, K[arl]. The flattening function of one-parameter spheroidal equilibrium figures. See Geophys. Abs. 186-451.

- 186-349. Mueller, Ivan I. The determination of the regional part of the vertical gradient anomaly by a geodetic method: Geofisica Pura e Appl., v. 48, p. 1-6, 1961.

For practical purposes, regional vertical gradients are the best values to use in reduction of observed gravity to sea level. This paper presents a method of determining regional vertical gradients in large areas from geodetic observations, which, added to the normal part, will give the regional vertical gradients. The regional vertical gradient anomalies for central Europe, computed from astrogeodetic deflections of the vertical, are shown on a map. Similar computation is under way for the United States. — D. B. V.

- 186-350. Burša, Milan. Bestimmung der Dimensionen des bestanschliessenden Ellipsoids für Europa auf Grund der astronomisch-geodätischen Daten des Katalogs IAG [Determination of the dimensions of the best-fitting ellipsoid for Europe on the basis of the astro-nomic-geodetic data of the IGY catalog (with Russian summary)]: Československá Akad. Věd Studia Geophys. et Geod., v. 4, no. 4, p. 404-409, 1960.

The parameters of the best-fitting ellipsoid for Europe are calculated from astronomic-geodetic data given in the International Geophysical Year catalog, using both the translative and projective variants of the surface method. The results show that the catalog data provide an adequate basis for such calculations, and that the two variants are equally accurate. The mean of the values obtained for the ellipsoid parameters are $a=6,378,112$ m, $\alpha=1:298.4$, $\xi_0=+5''$, and $\eta_0=+2''$ (a =major semiaxis, α =polar flattening, ξ_0 and η_0 =deflections of the vertical). These values are closest to those of the Krassovskiy ellipsoid. Comparison with the best-fitting ellipsoids determined for the U. S. S. R. and North America suggests that the geoid surfaces on the continental areas of the northern hemisphere can be replaced by a common ellipsoid, preferably the Krassovskiy. (See also Geophys. Abs. 182-252.) — D. B. V.

- 186-351. Bonchkovskiy, V. F., and Skur'yat, A. N. Urovennyy variometr UV [The leveling variometer UV]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 79-90, 1961.

The paper describes, analyses mathematically, and discusses a tiltmeter for continuous recording or visual observation of small variations in altitude between two or several points on the earth surface from tens to hundreds of meters from each other. The instrument is based on the principle of "connected vessels," in which the temperature gradient in the ambient air, variation in atmospheric pressure, air humidity, and the evaporation of liquid in the vessels have been taken into account. — A. J. S.

GEOTECTONICS

- 186-352. Dietz, Robert S. Continent and ocean basin evolution by spreading of the sea floor: Nature, v. 190, no. 4779, p. 854-857, 1961.

A "spreading sea floor" concept is proposed to explain sea-floor bathymetry. This concept requires the acceptance of a specific crustal model that is slightly at variance with the present consensus of opinion. The model is described. The oceanic "crust" (the gabbroic layer) is almost wholly coupled with convective overturn of the mantle creeping at a rate of a few cm per yr. The sea floor is essentially the outcropping of the mantle; it thus marks the tops of convection cells and slowly spreads from zones of divergence to those of convergence. The gross structures of the sea floor are direct expressions of this convection, and much of the minor sea floor topography may be too. Conditions deep within the mantle control the convective pattern without regard for continent positions. By viscous drag, the continents initially are moved

along with the sima until they attain a position of dynamic balance overlying a convergence; there they come to rest, but the sima continues to shear downward beneath them. If new upwells happen to rise under a continent it tends to be rifted; thus, North and South America were separated from Europe and Africa. In their normal position over convergences the continents are under compression from both sides and tend to buckle; in contrast, the ocean basins are domains of tension. If a continental block is drifted along with the sima the margin is tectonically stable, but if the sima slips under it, marginal mountains tend to be formed.

This hypothesis conserves the volumetric capacity of the oceans, unlike contraction or expanding earth theories. It provides a more plausible mechanism of continental drift, and explains the fact that the continents have stood high throughout geologic time despite erosion. It also fits well with the marine geologic evidence that the sea floor is young though the ocean basins are old, and with the stress pattern indicated by magnetic anomalies off the west coast of North America. — D. B. V.

- 186-353. Gilvarry, J[ohn] J. The origin of ocean basins and continents: *Nature*, v. 190, no. 4781, p. 1048-1053, 1961.

In a recent paper (see *Geophys. Abs.* 186-88) Gilvary suggested that the circular lunar maria are large meteorite craters with sedimentary floors excavated by explosive impact of meteorites on the lunar surface in the presence of a hydrosphere. Here he proposes an exactly analogous mode of formation of the ocean basins as the result of explosive impact of meteorites at a pristine time when the hydrosphere covered the earth to a roughly uniform depth. The conclusions presented here are identical in principle with Harrison's suggestions (see *Geophys. Abs.* 185-266), but the basis of the argument is entirely independent and the mechanism of crater formation is essentially different. — D. B. V.

- 186-354. Trümpy, Rudolf. Der Werdegang der Geosynklinale [The development of a geosyncline (with English summary, p. 700)]: *Geol. Rundschau*, v. 50, p. 4-7, 1960.

In the geosynclinal prehistory of many mountain chains there are two phases having different paleogeographic configurations, one characterized by tension tectonics, the other by compression tectonics. The climax of preorogenic magmatic activity coincides with an intermediate phase of gentle submarine topography. — D. B. V.

- 186-355. Geis, Hans-Peter. Frühorogene Sulfidlagerstätten [Early-orogenic sulfide ore deposits (with English summary, p. 694)]: *Geol. Rundschau*, v. 50, p. 46-52, 1960.

The Caledonian, Variscan, and Alpine orogenies were preceded by the formation of syngenetic lead-zinc-pyrite and chalcopyrite-pyrite deposits more or less parallel to the bedding. These were formed in subsiding basins and are arranged enechelon toward the higher parts of the sedimentary sequence, following definite laws. These laws can be used to interpret the mechanism of subsidence of parts of geosynclines. — D. B. V.

- 186-356. Cadisch, Joos. Der Oberbau der Orogene [The upper structure of orogens (with English summary, p. 691)]: *Geol. Rundschau*, v. 50, p. 53-63, 1960.

The arcuate form of mountain ranges is largely an expression of deep-seated tectonics. Apparently uniform arcs are often composed of different

segments, as in the case of the Rif and the Carpathians. Smaller marginal arcs are flow-forms, thrust over the surface. Aside from shear- and glide-planes parallel to the regional trend, which are part of the fold and nappe structure, fracturing plays a secondary role in the formation of alpine mountain ranges; misjudgment of the scale of ruptural processes has often led to overestimation of their tectonic role.

So far, the upper and lower levels of an orogen can be separated only on theoretical grounds. It is possible that the deep extension of orogens is limited mainly to their central zones. Where it has been possible to check, it has been found that the original width of depositional areas has not been overestimated. Too much importance is attached to gravity sliding. Later orogenic phases involve considerable tilting; this can be considered to be epeirogenic. — D. B. V.

- 186-357. Michot, Paul. Le problème des intrusions marginales [The problem of marginal intrusions (with English summary, p. 696)]: *Geol. Rundschau*, v. 50, p. 94-104, 1960.

The characteristic features of mafic eruptive manifestations in deep orogens are reviewed briefly, and their significance in catazonal orogens is examined in the light of the deep-seated catazonal monocyclic areas of southwest Norway. It is impossible for the mafic intrusions to have come from under the anorthosite masses that form the subbasement of the tectonic structure; they can only have been intruded laterally along the large recumbent folds that form the deeper parts of the orogen. These lateral intrusions are related to a "fundamental orogen," formed on the oceanic crust at the margin of a continental area, that develops into an orogen of deep catazonal type ("Grundgebirge" in the strict sense). The particular conditions engendered during the paroxysmal phase of orogenesis determine the formation of magmas at the oceanic margin of the orogen; these rise to form "marginal intrusions." In the deep part of the orogen these magmas are plagioclastic and give rise to the anorthositic foundation. — D. B. V.

- 186-358. Eskola, Pentti. Granitentstehung bei Orogenese und Epirogenese [Granite formation during orogenesis and epirogenesis (with English summary, p. 693)]: *Geol. Rundschau*, v. 50, p. 105-123, 1960.

The formation of granites is illustrated by examples from the Archean basement of Finland, where deep erosion has exposed horizontal sections through at least two orogens of different age. Four percent of the granitic rocks (including migmatites) that underlie 78.3 percent of Finland are epeirogenic granites, such as rapakivi. According to radioactive age determinations the basement rocks represent half of geologic time; therefore, it is uncertain whether granites were formed in the same way then as now, either qualitatively or quantitatively. In fact, many more granites were regenerated during the Archean Karelian orogeny than in any subsequent orogeny. — D. B. V.

- 186-359. Borchert, Hermann. Zusammenhänge zwischen Lagerstättenbildung, Magmatismus und Geotektonik [Relations between ore deposition, magmatism, and geotectonics (with English summary, p. 691)]: *Geol. Rundschau*, v. 50, p. 131-165, 1960.

Stille's concept that the sialic orogen and subsequent magmatism are of paligenetic origin is developed on the basis of petrologic and geophysical information on the nature of the crust. In the magmatic cycle the initial and final stages of simatic magmatism, drawing their basalts from 60 km or deeper in the crust, are interrupted only briefly by a "sialic intermezzo." The relations of the most important types of ore deposits to either the juve-

nile-basaltic magmatism or to the sialic-paligenetic melting are discussed. The geotectonic consequences of the occurrence of the two types of magmatism are discussed in detail. Deep fractures permit the rise of basaltic magmas. Subsidence of sial to 20-25 km leads to the mobilization of paligenetic magmas, which rise "backwards." The lubrication afforded by their rise makes paroxysmal folding possible in the geosynclinal crust. Sialic mountain roots cannot exist, but the silicic residues of basaltic magmas constitute a considerable introduction of sial into the upper crust during every orogeny. A 14-page bibliography is given. — D. B. V.

- 186-360. Amstutz, G. C. Some basic concepts and thoughts on the space-time-analysis of rocks and mineral deposits in orogenic belts: *Geol. Rundschau*, v. 50, p. 165-189, 1960.

The basic patterns underlying time and space analyses of ore deposits in orogenic and geosynclinal belts are reviewed. It is concluded that the present crisis in genetic concepts of rock and ore genesis will not be overcome without a fairly radical departure from conventional methods of analysis. An "integrated" appraisal, constantly including contemporary knowledge of other fields of science, philosophy, and psychology in addition to detailed observations and experiments, is required. — D. B. V.

- 186-361. de Sitter, L. U. Compression and tension in the earth's crust: *Geol. Rundschau*, v. 50, p. 219-225, 1960.

Variations in density in the basaltic layer and upper mantle are postulated as being due to phase transformations resulting from high temperature and pressure variations. This theory is developed to explain the elevation of mountain systems, median ocean rises, and deep sea trenches in terms of compressional and tensional stress fields. In this theory, orogenesis consists of three phases: (1) compression, conversion of basalt to eclogite, formation of deep basins by isostatic sinking and tectonic thrusting, deposition of flysch; (2) strong compression, shortening of cross-section, considerable thickening of sialic crust upwards and downwards accompanied by tectonic uplift; and (3) tension, faulting, conversion of eclogite to basalt, isostatic uplift.

Magmatic phases develop along with these and influence the average density of the mountain chain or parts of it. The initial magmatic phase with basic intrusions and pillow lavas occurs during the geosynclinal stage; regional metamorphic changes occur during the phase of strong compression; and intrusive phases coincide with the phase of tension. — D. B. V.

- 186-326. Egyed, L[ászló]. On the mechanism of mountain building and folding: *Geol. Rundschau*, v. 50, p. 225-234, 1960.

Mountain building and associated phenomena are explained in terms of the expanding earth theory. The geosynclinal phase is connected with deep fractures, accompanied by deep sea troughs, isostatic anomalies, and andesitic volcanism. The phase of emergence is accompanied by the formation of rift zones, which in turn are connected with shallow earthquakes and basaltic volcanism. Folding occurs during and immediately after the geosynclinal phase, due to the lateral pressure of intruding magmas and later by gravity sliding of accumulated sediments. — D. B. V.

- 186-363. Hiersemann, L[othar]. Seismotektonik in Bereich junger Orogene [Seismotectonics in the domain of young orogens (with English summary, p. 694)]: *Geol. Rundschau*, v. 50, p. 235-250, 1960.

Earthquakes are the clearest expression of recent tectonics. According to the uniformitarianism principle, the study of focal mechanisms should offer real clues to the development of orogens. The mechanics and dynamics of earthquakes are reviewed briefly, and the theoretical possibilities of the dynamic interpretation of the kinematic parameters are indicated. The north-west Pacific margin of Asia is discussed as an example of a seismotectonically active young orogen. The dynamic interpretation by the Japanese agrees well with the geology of the area, but the fault-plane solutions are ambiguous and cannot yet be accepted as final. — D. B. V.

- 186-364. Pannekoek, A. J. Post-orogenic history of mountain ranges: *Geol. Rundschau*, v. 50, p. 259-273, 1960.

Late folding, fracturing, and differential vertical movements constitute the morphogenetic phase of an orogeny; these differential movements and erosion together determine the morphology of mountains during their later history. Morphogenetic movements are independent of the earlier orogenic history. Any theory of orogenesis must also explain the morphogenetic phases; isostatic uplift as a result of erosion is considered inadequate. The connection of morphogenetic movements with post-orogenic volcanism suggests the possible importance of magmatic processes.

The collapse of large basins with positive gravity anomalies, such as the Mediterranean, may be related to the uplift of neighboring mountain chains; it seems to be independent of orogenic structures. — D. B. V.

- 186-365. Kraus, Ernst C. Über Definition und Wesen des Orogens [On the definition and nature of the orogen (with English summary, p. 695)]: *Geol. Rundschau*, v. 50, p. 292-298, 1960.

The history of the changing usage of the term "orogen" is traced, together with consideration of the nature of geosynclines and orogens. The geosynclinal orogen is defined as a bilaterally outward-diverging structure of the young earth's crust, developed from a longitudinal marine zone some 1,000-2,000 km long that tended mainly to sink throughout millions of years. Under orokinetic-magmatic, facies, and seismic-morphologic attendant circumstances conducive to high mobility, the sialic crust thickens downward to as much as 40 km. In the last stage the orogen rises isostatically to form mountains; as erosion progresses toward peneplanation, the uplift becomes relatively stable. — D. B. V.

- 186-366. Sonder, R[ichard] A. Kritische Gedanken zur orogenen Problematik [Critical opinions on the orogen problem (with English summary, p. 700)]: *Geol. Rundschau*, v. 50, p. 298-315, 1960.

The essential elements required for constructing a general theory of orogenesis are reviewed. Individual geologic arguments, which are based on unprovable assumptions, are evaluated in terms of their mechanical feasibility. Without mechanism studies, only the most superficial and questionable insight into geotectonics can be obtained.

The contraction hypothesis is considered to have the best chance of fulfilling all the major requirements of a general theory of orogenesis, but it is inadequate in the elaboration of details; other theories meet the basic requirements only in part. — D. B. V.

- 186-367. Belousov [Belousov], V. V. Tectonic map of the earth: *Geol. Rundschau*, v. 50, p. 316-324, 1960.

The tectonic map of the world compiled by Belousov shows regions of continental and oceanic crust; within the former it shows Alpine geosynclines and Alpine platforms, the latter subdivided according to the age of the basement. Anticlines, synclines, and tectonically active regions on platforms are marked.

The map is based on the concept that in the course of earth history the oceanic type of crust is secondary with respect to the continental type. During the geosynclinal-platform, or granite stage the granitic continental crust was formed. During the basalt stage, superheated basalts rose from deep in the mantle; surface manifestations of this stage are tectonic activity, extrusion of plateau basalts, and "oceanization"—secondary transformation of the granite-basalt continental crust into the water-basalt oceanic crust. Theories of mobilism of any kind are categorically rejected; the continuously stable geographic location of many regions of uplift and subsidence of the crust of the continents shows that these regions stay over the same part of the mantle wherein lie the causes of these vertical movements. — D. B. V.

- 186-368. Bemmelen, R. W. van. Zur Mechanik der ostalpinen Deckenbildung [On the mechanics of nappe formation in the East Alps (with English summary p. 690)]; Geol. Rundschau, v. 50, p. 474-499, 1960.

Three genetic profiles through Salzburg and the Hohe Tauern show that the East Alpine orogeny can be explained better by gravitational tectonics than by tangential pressure. Nappes of Helvetic type are formed where the skin of Alpine sediments glides off, and nappes of East Alpine type where the basement is also involved in the lateral movement; nappes of Penninic character are formed by flow in deeper, rheomorphic parts of the crust. The gravitational explanation does not require crustal shortening; this agrees with seismic and gravimetric data. — D. B. V.

- 186-369. Goodman, A. J. Review of some hypotheses on mountain building: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 8, p. 215-227, 1960.

This paper reviews recent concepts of mountain building. Bucher's ideas and experiments, representing the contraction viewpoint with emphasis on horizontal stress, are considered. Belousov's contention that vertical stress is the prime factor in mountain building is also mentioned together with the views of others who challenge the overall décollement idea as exemplified in Buxtorf's Jura interpretation. Carey's revolutionary concepts, which include an expanding earth, continental drift, and the interlocking on a global scale of all major tectonics, are given consideration and related to earlier concepts by others. — Author's abstract

- 186-370. Deutsch, E. R. First-order tectonics of North America—A review: Alberta Soc. Petroleum Geologists Jour., v. 8, no. 8, p. 228-232, 1960.

Deutsch reviews the comments made by Warren S. Carey in an introduction to a symposium in Calgary, Canada, on the structure of western North America. The chief structural features of western North America can be understood if the action of a dextral shear couple along the Pacific coast is invoked. To account for the couple, Carey's concept of the orocline (see Geophys. Abs. 163-201; 176-165) must be considered. By unbending the kink in the Alaskan orocline both the Arctic Basin and the North Atlantic Ocean are closed off; a certain continental motion—chiefly rotational—is implied, and this would account for the shear movement of western North America relative to the Pacific Ocean. Two lines of corroborative evidence are cited: (1) present knowledge of seismicity in relevant regions; and (2) measurements of remanent magnet-

ism of rocks. Deutsch also notes that seismic evidence is not confined to distribution of earthquake focuses along the continental fracture systems but includes recent information from fault-plane analysis showing that much of the faulting is transcurrent in type. The features of the bold tectonic pattern of western North America (see Geophys. Abs. 178-217) are discussed, and it is concluded that the tectonics of the whole great region are dominated by structures manifesting dilation at one end, compression at the other, and shear in the center. Continental drift can be inferred only if polar traces deduced from paleomagnetic results on two or more continents fail to coincide. Confirmation of a dextral shear couple along the west coast of North America by paleomagnetism must await examination of suitable rocks from the adjacent deep ocean. — V. S. N.

- 186-371. Alberta Society of Petroleum Geologists. Discussion—Perspectivities in the solar system: Alberta Soc. Petroleum Geologists Jour. v. 9, no. 5, p. 162-173, 1961.

Haites' recent paper "Perspectivities in the solar system" (see Geophys. Abs. 185-265) is discussed by Gretener (p. 162-164), Holland (p. 164-165), and Hall (p. 165-167). Haites' answer (p. 168-173) includes a wire-diagram which, with figures 2 and 4 of the original paper, he feels demonstrates better than words or formulas what the perspectivities try to accomplish. — V. S. N.

- 186-372. Egyed, L[ászló]. The expanding earth: New York Acad. Sci. Trans., ser. 2, v. 23, no. 5, p. 424-432, 1961.

This is an English version of Egyed's expansion theory to explain the internal constitution and structure of the earth. For previous publications of this theory see Geophys. Abs. 167-165, 171-203, 173-236, 177-178, 178-215, 182-58, and 183-325. — V. S. N.

- 186-373. Jordan, P. Zum Problem der Erdexpansion [On the problem of the earth's expansion]: Naturwissenschaften, v. 48, no. 11, p. 417-425, 1961.

The concept of an expanding earth is reviewed. The ideas of Ewing and others (see Geophys. Abs. 181-490) concerning a globe-girdling system of oceanic rifts; Binge's early analysis of volcanism and intrusion as supporting the strong expansion hypothesis; strong expansion as advocated independently by Fisher, Egyed, and Heezen, and expansion based on Dirac's cosmology (see Geophys. Abs. 182-58, -281) are discussed. The theory of strong expansion can well explain continents and oceans; its application to the earth's interior is more difficult but possible. — D. B. V

- 186-374. Belousov [Belousov], V. V. The origin of folding in the earth's crust: Jour. Geophys. Research, v. 66, no. 7, p. 2241-2254, 1961.

Folding represents the reaction of layered beds to differential vertical movements of separate blocks of the crust. Block folding is the most direct reaction to these movements, and characteristically produces box-like folds; they may occur either in platforms or geosynclines. Injection folding is due to horizontal flow of the more plastic rocks, which are squeezed out from some areas and accumulate in others; such flow results from uneven loading by overlying layers and, particularly, from fracturing of these layers, and occurs mainly in foredeeps and tectonic basins. Metamorphic or deep folding is connected with granitization and metamorphism; when rock density be-

comes lower due to impregnation by volatile substances, upward flow is induced and deep diapir-like structures are formed. General crumpling is the result of gravitational sliding of layers down the slopes or the spreading of the upper parts of uplifted blocks; horizontal compressive forces are created which crumple adjacent layers. General crumpling can also be formed by mechanical pushing apart due to the formation of injection cores or deep diapirs. Deep folding and general crumpling occur in geosynclinal belts.

Folding phenomena do not indicate the existence of general compressional forces in the crust; horizontal compression is a purely local phenomenon limited to narrow belts within geosynclines. The primary cause of folding is vertical movements. — D. B. V.

- 186-375. Sheynmann, Yu. M. Znacheniyе океанов атлантичeskого tipa dlya razvitiya struktur Zemli [Significance of oceans of the Atlantic type for the development of the structure of the earth]: Moskov. Obshch. Ispytateley Prirody Byull. Otdel Geol., v. 36, no. 2, p. 29-38, 1961.

Oceans of the Atlantic type are younger than the structures that surround them; they form by the destruction of these structures. The same type of destruction of older structures by younger is observed at the junction of the ancient structures of old platforms with the folded belts that frame them. The Atlantic and Indian Oceans are in the very first pregeosynclinal stage and further development will lead to the appearance of broad primary geosynclines. Ocean development does not encompass the entire earth. The formation of new folded belts is distinctive of part of the earth, but elsewhere older folded structures continue to develop. — J. W. C.

- 186-376. Subbotin, S. I. Prychyny tektonichnykh rukhiv ta mekhanizm formuvannya osnovnykh heostrukturnykh elementiv zemnoy kory [Causes of tectonic movements and mechanism of formation of the fundamental geostructures of the earth's crust (in Ukrainian with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 22, no. 5, p. 3-17, and no. 6, p. 3-16, 1960.

Analysis of gravity and other data suggests that volume changes in subcrustal matter are the most likely cause of vertical movements in the crust. The changes occur intermittently at depths of 60 or 80 to 800 or 900 km and may be due to polymorphism, phase transformations, electron migration, or chemical reactions. Each of these factors is discussed in some detail in the first part of the paper. The second part treats the formation of depressions in platform areas, deep fractures, geosynclines (and their folding), and the deep basins of intracontinental seas (such as the Black, Caspian, and Aegean Seas) as a result of vertical movements. Numerous diagrams and a 54-entry bibliography are given. — D. B. V.

- 186-377. Quiring, Heinrich. Der Rand der Mondnarbe im Pazifik [The rim of the moon scar in the Pacific]: Neues Jahrb. Geologie u. Paläontologie Monatsh., no. 3, p. 140-150, 1961.

The lack of sial crust and the ascent of ultramafic magmas suggest that in the north Pacific the sial crust, with an average thickness of 16 km, was probably torn away catastrophically to form the moon, allowing sima magma to rise to the level of isostatic equilibrium and fesima magma to about 75 km below this level. The magmas rose only to within 5 km of the geoid surface, leaving the Pacific basin. The catastrophe rocked the whole earth; this was the Laurentian revolution. The earth's radius was shortened by some 42 km

and the primitive crust, settling in over the magmas that flowed toward the scar, was compressed, heated, and permeated by gases.

The Laurentian revolution was the strongest of all crustal movements; the primitive crust is nowhere preserved, whereas all later movements have been limited to more or less extensive zones of weakness between stable cratons. The rim of the moon scar is clearly discernible in the form of circum-pacific Archean fault systems. Other evidence of the moon's ejection consists of the ring of deep sea troughs, volcanoes, and earthquake zones surrounding the north Pacific. — D. B. V.

186-378. Hodgson, R. L. Drift or shift: Univ. Sheffield Geol. Soc. Jour., v. 4, no. 2, p. 18-22, 1961.

Five current hypotheses to explain the shift in position of the geomagnetic pole from Precambrian to Recent times and to explain the discrepancy in longitude and latitude of the pole positions from continent to continent are discussed as follows: (1) the direction of magnetization of the rock today does not represent the direction of the local earth's field at the time of magnetization; (2) the earth's crust as a whole has shifted relative to the axis resulting in wandering of the geographic pole; (3) the crust has remained fixed but the geomagnetic field in the past corresponded to a dipole not directed along the rotational axis, resulting in wandering of the magnetic pole; (4) the earth's field had strong nondipole components in remote geological times; and (5) continental drift has occurred. Scientific opinion in general seems to conclude that both continental drift and polar wandering have occurred and are the important factors although Blackett and others (see Geophys. Abs. 184-491) believe polar wandering is unimportant. — V. S. N.

186-379. Joplin, Germaine A. On the tectonic environment of basic magma: Geol. Mag., v. 97, no. 5, p. 363-368, 1960.

It is shown that basic magma is associated with vertical and not with folding movements, that basic intrusions take on forms characteristic of unfolded regions and of relatively high levels, and that differentiation in place is common. Basic magma is emplaced in the orogenic belts as flows and typically nonorogenic intrusions during the geosynclinal or sinking phase of the orogenic cycle. The terms "Nonorogenic Association" and "Orogenic Association" are suggested to replace "Volcanic Association" and "Plutonic Association" to indicate the relation of basic and silicic magmas to their tectonic environment. — V. S. N.

186-380. Richter, C[harles] F. Comparison of block and arc tectonics in Japan with those of some other regions: Jour. Physics of Earth [Tokyo], v. 8, no. 1, p. 1-10, 1960.

Most of the seismicity of the world is related to the two principal environments—block and arc tectonics; the latter is found chiefly in the circum-pacific and Alpine belts. Distinction between block and arc structures is usually not one of essential character but one of the present stage of development. Block tectonics may be considered as a later stage which follows the folding and thrusting of a typical orogeny. It represents a lower degree of activity than the arc stage; large shallow earthquakes are common, intermediate are rare, and deep are absent; volcanoes are in a late stage of activity or extinct; and foredeeps and gravity anomalies are less pronounced than in an active arc.

In Japan, block and arc structures occur in a geometrical and mechanical relationship that promises to shed light on the nature of both. The five subdivisions in Japan are discussed as follows: (1) west Japan (the main islands

west and southwest of the Fossa Magna) a major area of block tectonics with only traces of arc features; (2) northeast Japan, (Honshu east of the Fossa Magna and southwest Hokkaido) a part of a major Pacific arc with block faulting in the interior in a belt adjacent to the Japan Sea; (3) northeast Hokkaido, terminus of the active Kuril Arc; (4) the Ryukyu Islands Arc, which extends into Kyushu to intersect and modify the block structure; and (5) the Shichito Arc extending south to the Ogasawara (Bonin) Islands. The tectonic characteristics of these subdivisions are compared with those of New Zealand, California and the Great Basin area, the East Indies, the West Indies, the Himalayan Arc, the Italian Arc, and the tectonics of the U. S. S. R.

A statistical study of the proportion of large to smaller earthquakes is recommended as a valuable means of distinguishing between areas of different tectonic type. Statistical results in the Pamir-Baikal seismic belt show a higher proportion of large to small earthquakes than in the Pacific arcs and suggest an area of block tectonics. — V. S. N.

186-381. Inoue, Eiji. Land deformation in Japan: Japan Geog. Survey Inst. Bull., v. 6, pt. 2-3, p. 73-134, 1960.

Recent land deformations in the Japanese Islands based on data from local geodetic surveys compared with data from the original geodetic network are discussed and illustrated for major earthquakes from 1891 to 1952. A recent and almost completed revision of the primary geodetic network of the Japanese Islands substantiates the belief derived from earthquake displacements that there are regional crustal movements in Japan that are continuous over a period of several decades. The horizontal and vertical displacements deduced from a comparison of the results of the present and previous geodetic surveys (60 yr interval) are shown in figures. These comparisons indicate that deformation is systematic in each region and seems to be closely related to the present topography of the Japanese Islands. The types of displacements directly related to earthquakes and the horizontal and vertical movements of secular crustal displacements are discussed in detail and illustrated for various areas of Japan. Major gravity anomalies are located, and their relation to secular crustal deformation is discussed.

It is concluded that present crustal movements in the Japanese Islands are caused by lateral pressure of the Asian Continent on the Pacific Ocean basin or by a contraction pressure between the continent and ocean basin acting continuously at least since early Cenozoic and resulting in land deformations characterized by the interaction of arc structures. — V. S. N.

186-382. Blake, Weston, Jr. Russian settlement and land rise in Nordaustlandet, Spitsbergen: Arctic, v. 14, no. 2, p. 101-111, 1961.

The evidence from a Russian hut on Nordre Russøya, an island in Murchisonfjord, Nordaustlandet, Spitsbergen, that is at least 100 years old and is now only 1.2 m above highest tide indicates that land uplift in this area is very slight if it is occurring at all; a rise of 1 m or more per century would put this hut under water when it was built. No long term observations on land rise are available from this area, but it appears that such a rise is measurable at most in terms of a few centimeters per century; if slow isostatic uplift of the land is occurring, it is balanced by the present eustatic rise of sea level. Present stability is further indicated by the well-developed shingle beachbars that are generally lacking at higher levels on the raised beaches. — V. S. N.

186-383. Christiansson, Hans. The Russian settlement at Russekeila and land rise in Vestspitsbergen: Arctic, v. 14, no. 2, p. 112-118, 1961.

Evidence from the ruins of a Russian settlement at Russekeila, Isfjorden, Vestspitsbergen, indicates that there has been no appreciable land rise in at least 100 years. This is in accord with evidence from Murchisonfjord (see Geophys. Abs. 186-382) and elsewhere in northwestern Vestspitsbergen. At Amsterdamøya, an island off northwest Vestspitsbergen, no significant change in the relation between land and sea has occurred for more than three centuries. — V. S. N.

GLACIERS

- 186-384.** Sharp, Robert P. *Glaciers*: Eugene, Univ. Oregon Press, Condon Lectures, 78 p., 1960.

Some basic facts are presented as background for an understanding of certain facets of modern glaciological research. The Blue, Saskatchewan, and Malaspina-Seward glaciers are used as examples to illustrate the various phenomena under discussion. The seven chapters, originally given as lectures, are: the constituent parts of a glacier, the glacier budget, glaciers and climate, the conversion of snow to glacier ice, the flow of glaciers, structures in glaciers, and oxygen-isotope ratios. — V. S. N.

- 186-385.** Wilson, Charles R., and Crary, A. P. Ice movement studies on the Skelton Glacier: *Jour. Glaciology*, v. 3, no. 29, p. 873-878, 1961.

During the 1958-59 Victoria Land Traverse operations, 12 major geophysical stations were occupied on Skelton Glacier on the west side of the Ross Ice Shelf, and seismic, gravity, magnetic, and glaciological studies were made; other sites were occupied for intermediate gravity and elevation observations. Included in the studies were detailed measurements of ice thicknesses, water depths, absolute and relative movements along a 16 km line across the floating mouth of the glacier near Teall Island, and 2 movement studies on the northeast branch of the upper grounded glacier at an elevation of 372 m. The floating part of Skelton Glacier seems to be moving as a solid block with nearly constant velocity; the amount of movement was calculated as 88.7 m per yr or an annual volume of flow of $791 \times 10^6 \text{ m}^3$. At the observation points on the upper glacier the yearly absolute value of movement at the surface was determined to be 75 m or an annual volume of flow of $245 \times 10^6 \text{ m}^3$.

Estimates of the local ice regime are reported from two sites on the glacier where ice thickness and strain rates are known. It is inferred that thinning of the ice must take place in the direction of motion. The thinning necessary for an absolute movement of 75 m per yr would be 20 m per km. — V. S. N.

- 186-386.** Sil'nitskaya, V. I., and Cheremnykh, G. D. O metodike izmereniya skorostey dvizheniya l'da poverkhnostnykh chastey nekotorykh lednikov v Antarktiki po materialam dvukratnoy aerofotos"emki [On the method of measurement of the surface flow rates of some glaciers in Antarctica according to data of two aerophoto surveys]: *Akad. Nauk SSSR Izv. Ser. Geog.*, no. 5, p. 90-95, 1959.

Two aerophoto surveys over the same glacier in Antarctica in the years 1956 and 1957 showed displacements of markers on the glacier. The flow rate was determined to be about 40 m per month. — A. J. S.

GRAVITY

- 186-387. Gamow, George. Gravity: Sci. American, v. 204, no. 3, p. 94-100, 102-104, 106, 1961.

A popular and well-illustrated account is given of the history of gravitational theory. Major emphasis is given to a discussion of Einstein's theory that gravitation can be interpreted as a geometrical property of space-time. Einstein's efforts to relate gravity and electromagnetism through his "unified field" theory, which has been largely rejected by modern scientists, are also discussed along with the more recent approach, as expressed by Gamow, that the true relation between gravitational and electromagnetic forces is to be found through an understanding of the nature of elementary particles and of the relation between the masses and the electric and magnetic properties of the particles. Dirac's proposal that the value of the constant ratio that is found by comparison of the actual strength of the electrostatic and gravitational forces between a pair of particles is a factor of the age of the universe is examined. It is further shown that if, in the future, it should be demonstrated that antiparticles have a negative gravitational mass, Einstein's principle of equivalence and thus the entire relativistic theory of gravity will have been disproved. — V. S. N.

- 186-388. Tengström, Erik. Calculation of the external gravity anomalies and deflections of the vertical at higher elevations by means of Taylor expansions from the geoid: Ohio State Univ. Inst. Geodesy, Photogrammetry, and Cartography Repts., no. 5, 15 p., 1959.

This paper is a continuation of Tengström's paper (1959) on the boundary value problem of physical geodesy. The gravity anomalies Δg and geoid undulation values N at sea level are used; the disturbing potential T , the gravity anomaly Δg , and the components ξ and η of the deflection of the vertical are expanded in Taylor series of altitude h . These formulas give the quantities T_h , Δg_h , ξ_h , and η_h at elevations up to 150 km. — D. B. V.

- 186-389. O'Keefe, John A., Eckels, Ann, and Squires, R. Kenneth. The gravitational field of the earth: Astron. Jour., v. 64, no. 7, p. 245-253, 1959.

It is shown that all of the 222 elements of the orbit of the Vanguard I satellite (1958 β 2) for the 37 epochs since its launching can be derived from the zonal harmonics of the earth's gravitational field of degrees 0, 2, 3, and 4, together with 6 initial elements and the values of the mean anomaly. (See also Geophys. Abs. 180-183.) — D. B. V.

- 186-390. King-Hele, D. G. The earth's gravitational potential, deduced from the orbits of artificial satellites: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 3-16, 1961.

This is a more detailed version of the paper published in Nature, v. 187, no. 4736, p. 490-491, 1960 (see Geophys. Abs. 183-314). — D. B. V.

- 186-391. Merson, R. H. The motion of a satellite in an axi-symmetric gravitational field: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 17-52, 1961.

The equations for the variation of the osculating elements of a satellite are integrated to yield the complete perturbations of the first order due to the sec-

ond harmonic, together with the secular perturbations of the second order due to the second harmonic and of the first order due to the third to sixth harmonics. A set of smoothed elements is then derived, in which the perturbations of the even harmonics have no singularities, the semimajor axis and eccentricity have no variation due to the second harmonic and the other elements have the smallest possible amplitudes of oscillation. The formulas presented will be extremely useful in the reduction of earth-satellite observations and geopotential studies based on these. — Author's summary

- 186-392. Cook, A[lan] H[ugh]. Resonant orbits of artificial satellites and longitude terms in the earth's external gravitational field (with appendix by H. J. Norton): Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 53-72, 1961.

As there is little prospect at present of finding the longitude-dependent parts of the earth's external gravitational potential from the motion of an arbitrary satellite, it is of interest to see if in special circumstances long-period or secular perturbations could arise in these parts. A preliminary study of satellite orbits with periods bearing some specific relation to the period of the earth's rotation shows that secular and long-period perturbations can arise. In the appendix it is shown that many resonant orbits are possible besides those given in the main body of the paper. — D. B. V.

- 186-393. Tsuboi, Chuji. Numerical tables useful for studying the gravitational field at higher elevations of the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 73-82, 1961.

Expressions for the gravitational potential and force at a point (not necessarily on the earth's axis) at any higher elevation of the earth have been obtained in a simple summation series form in terms of zonal averages of surface gravity anomalies taken around the axis passing through the point. Numerical values to be multiplied to zonal averages of gravity anomalies in order to obtain the potential and force are given in tables. If the elevation is zero, our values for the potential naturally agree with those of Lambert's Q function. — Author's summary

Kaula, W[illiam] M. Analysis of gravitational and geometric aspects of geodetic utilization of satellites. See Geophys. Abs. 186-348.

- 186-394. Gladkiy, K. V. Otsenka razreshayushchey sposobnosti metodov raspredeleniya gravitatsionnykh poley [Evaluation of the resolving power of the methods of separation of gravity fields]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 685-693, 1961.

This is a mathematical analysis (information theory) of the problem of separating a necessary signal obtained with a geophysical apparatus from the interfering signals. Gravity anomalies observed and observation errors are treated as probability functions, and the resolving power of the methods of separation of gravity fields are investigated. The evaluation of the resolving power and the selection of optimum parameters in determination of higher derivatives in the upper half-space are discussed. — A. J. S.

- 186-395. Afanas'yev, N. L. Sglazhivaniye gravitatsionnykh anomalii [Smoothing of gravity anomalies]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 994-1003, 1961.

A method for smoothing gravity anomaly curves on the basis of the theory of probability, proposed in 1935 by Whittaker, is discussed. The method secures

the actual value of the mass and correct coordinates of the center of gravity of the anomalistic body. Graphical examples of smoothed anomaly curves, and auxiliary tables are given. — A. J. S.

- 186-396. Tsuboi, Chuji. Upward and downward continuation of gravity values based on the cylindrical co-ordinate system: Japan Acad. Proc., v. 37, no. 1, p. 37-41, 1961.

A method of gravity continuation by which the distribution of an underground mass may be determined from the surface anomaly is presented. The method is based on a cylindrical coordinate system that is superior to the rectangular system because the circular form of its relevant domain permits uniform extension in different azimuths. An example is illustrated in a figure and the mathematical solution given. The method is readily modified to solve for an upward continuation of gravity values. — V. S. N.

Troshkov, G. A. On the problem of interpretation of magnetic and gravity anomalies of three-dimensional bodies. See Geophys. Abs. 186-515.

Marussi, Antonio. Intrinsic coordinates in practical geodesy. See Geophys. Abs. 186-346.

- 186-397. Jackson, J. E. The Cambridge pendulum apparatus: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 375-388, 1961.

The three-pendulum method, developed and used by Lenox-Conyngham, was superseded in 1930 on the arrival of a new vacuum box for swinging two pendulums. With three invar pendulums taken over from the earlier apparatus and three new ones acquired in 1931, this box is the centerpiece of the apparatus which has been in use up to the present day for geophysical investigations and for establishing gravity reference stations in many parts of the world. This article describes briefly the apparatus and the various modifications of procedure and changes of auxiliary gear that have taken place in the past 30 years. A list of the work done with the apparatus is given. — Author's summary

- 186-398. Bancroft, A. M. The establishment of gravity bases at airports across Canada: Dominion Observatory Ottawa Pubs., v. 24, no. 2, p. 45-66, 1960.

Gravity base stations were established at 48 airports across Canada using the method of forward looping. The three gravimeters used were transported by aircraft. A complete tabulation of the observations and adjustments is given together with detailed station descriptions. Six closed circuits were formed within the network in order to make subsequent adjustments. Observations for each instrument were adjusted separately by a tabular iteration method which is described in detail, and instruments were calibrated by comparison with Cambridge pendulum data. All values are listed relative to that adopted for the National Reference Pier in Ottawa. The standard deviations of the observations are estimated to range from 0.2 mgal for stations near Ottawa to 0.5 mgal for stations in western Canada. — V. S. N.

- 186-399. Hamilton, Angus C. Gravity measurements in Canada—January 1, 1957 to December 31, 1959: Dominion Observatory Ottawa Pubs., v. 24, no. 3, p. 71-82, 1960.

A brief review is given of gravity measurements made in Canada from January 1, 1957 to December 31, 1959 by the Dominion Observatory, the National

Research Council, and other public institutions, universities, and industrial groups. The following are discussed: absolute measurements and connections to first order world stations, the national primary network, regional mapping, reconnaissance surveys and detailed studies of particular interest, isostatic and geodetic studies, and instrumental development. — V. S. N.

186-400. Dooley, J. C., and Williams, L. W. Absolute gravity value at Adelaide: *Australian Jour. Sci.*, v. 23, no. 1, p. 17-18, 1960.

In his assessment of the absolute gravity value at Adelaide, South Australia, Mumme (see *Geophys. Abs.* 182-209) was apparently unaware of several recent developments in establishing a gravity datum for Australian stations generally. The currently adopted value for the New Observatory Base at Adelaide is 979.7228 gal, based on the Melbourne value which in turn is based on Cambridge. International gravimeter connections suggest that this is a little too low.

The suggestion for establishing a permanent gravity station is admirable, but the value should not be recorded permanently on a brass plug as it is liable to readjustment in the near future. The Potsdam reference system is being revised; the first order international network, which includes Melbourne, will probably be adjusted within the next two years; and values of gravity stations within Australia will then be adjusted internally. — D. B. V.

186-401. Stott, P. M. Gravity observations in Tasmania: *Australian Jour. Sci.*, v. 23, no. 9, p. 300-301, 1961.

Gravity readings between the old base station at Cambridge Airport and the new station at Llanherne Airport in Tasmania were made with a Worden No. 61 gravimeter. Observations were also made at 6 other points in Tasmania for use as base stations for future measurements. Results, referred to the Footscray (Melbourne) value which is based on the Cambridge (England) value, are tabulated. — D. B. V.

186-402. Harada, Yoshimichi; Suzuki, Hiromiti; Ohashi, Shin-ichi; and Kakinuma, Seiichi. Determination of the differences in gravity between Chiba, Singapore, Cape Town and Syowa Station in Antarctica: *Japan Geog. Survey Inst. Bull.*, v. 6, pt. 2-3, p. 135-156, 1960.

The results of gravity measurements carried out during the 2d, 3d, and 4th Japanese Antarctic Research Expeditions at Singapore, Capetown, and Syowa Station in Antarctica are summarized (see also *Geophys. Abs.* 177-219, 184-409). The difference in values determined in 1957-58 using a GSI pendulum apparatus are as follows:

$$\text{\textcircled{S}}_{\text{Singapore}} - \text{\textcircled{S}}_{\text{Chiba}} = -1709.3 \pm 0.45 \text{ (mean error) mgal}$$

$$\text{\textcircled{S}}_{\text{Capetown}} - \text{\textcircled{S}}_{\text{Chiba}} = -142.8 \pm 0.45 \text{ (mean error) mgal}$$

Using a gravity value for Chiba of 979.7898 relative to the national fundamental station at Kyoto, Japan, of 979.7215, the following values are obtained: $\text{\textcircled{S}}_{\text{Singapore}} = 978.0805 \text{ cm per sec}^2$, and $\text{\textcircled{S}}_{\text{Capetown}} = 979.7215 \text{ cm per sec}^2$. The gravity value at Syowa station determined in 1958-59 by a Worden gravimeter is $982.540 \text{ cm per sec}^2$ relative to the Capetown value. The Syowa results were further checked in 1959-60, and gravity values were determined for 5 stations in the Ongul Islands. Observations on pack-ice in Lützow-Holm Bay show a gravity anomaly of more than +50 mgal, whereas those in the Ongul Islands are about -10 mgal. It is concluded that a large gravity gradient exists along the coast of Lützow-Holm Bay. — V. S. N.

- 186-403. Suzuki, Hiromiti; Ohashi, Shin-ichi; and Kakinuma, Seiichi. Report of the gravity measurement by the Japanese Antarctic Research Expedition, 1959-60 [in Japanese with English abstract]: Antarctic Rec., no. 12, p. 37-44, 1961.

During the fourth Japanese Antarctic Research Expedition, 1959-60, a re-measurement was made of the gravity value at Astronomical Point, Syowa Station, Antarctica, previously determined in 1958-59. The mean value, 982.5427, was only 2.6 mgal higher than the 1958-59 value and, therefore, the 1958-59 value is considered accurate enough to be used as a reference value in gravity measurements in this district.

On the way to and from Antarctica 10 gravity stations were reoccupied and 10 new stations were established on Singapore Island; observations were also carried out in Naha, Ryūkyū. Results are given in tables. — V. S. N.

- 186-404. Garland, G. D., Kanasewich, E. R., and Thompson, Thomas L. Gravity measurements over the southern Rocky Mountain Trench area of British Columbia: Jour. Geophys. Research, v. 66, no. 8, p. 2495-2505, 1961.

A series of negative gravity anomalies found along the southern part of the Rocky Mountain Trench in Canada is interpreted to be the effect of relatively deep basins in the trench floor. These are apparently filled with light material and are separated from each other by regions of only thin cover over bedrock of normal density. The pattern obtained is very suggestive of a system of longitudinal and transverse faults, and the gravity field is therefore consistent with the theory that the trench, in this vicinity, was produced chiefly by downfaulting. — Authors' abstract

- 186-405. Murphy, Thomas. Gravity anomaly map of Ireland, Sheet 5—South West: Dublin Inst. Adv. Studies Geophys. Bull., no. 18, 2 p., 1960.

The gravity (Bouguer) anomaly map presented here is one of a series designed to give a complete gravity coverage of Ireland. In the area of this sheet, the value of the gravitational field has been determined at about 2,300 stations approximately 3 km apart. Measurements were made with a Worden gravimeter, and the base stations used are those of the Irish network with a few interpolated ones. The map, on a scale of 1:250,000, covers the area of southwest Ireland between lat 51°18'—52°40' N. and long 07°43'—10°30' W. A brief description is given of the anomaly field which, in general, is positive with an average value of 8 mgals. Few gravity features can be correlated with the surface rocks; one of the better defined features is a low trough running east-west that coincides with a syncline of Carboniferous limestone in Devonian rocks. The most striking feature of the sheet is the large negative anomaly south of Killarney and connecting to the east with one north of Cork. A strong positive anomaly to the north of Killarney on the Dingle Peninsula produces a very steep gradient between the two areas. The cause is associated with deep-seated rock formations. — V. S. N.

- 186-406. Bullerwell, W. The gravity map of Northern Ireland: Irish Naturalists' Jour., v. 13, no. 11, p. 254-257, 1961.

The revised gravity map of Northern Ireland, compiled from gravity surveys during the summers of 1959 and 1960, is discussed. Some 10,488 new gravity stations extending throughout Northern Ireland and spaced at about 2 stations per square mile were occupied during the surveys. A Bouguer anomaly map summarizing the survey results is presented and the major features

described. The average gravity anomaly for Northern Ireland is +20 mgals, and except for County Down the contours show an arrangement along Caledonian trends. — V. S. N.

- 186-407. Whetton, John T., Myers, J. O., and Burke, K. B. S. Tracing the boundary of the concealed coalfield of Yorkshire using the gravity method: *Mining Engineer*, no. 8, p. 657-668, 1961.

A gravity survey was made to determine the structures from the edge of the concealed coalfield of West Yorkshire into the drift-concealed Vale of York. The gravity measurements, which cover an area of more than 200 sq mi, reveal anomalies that indicate a well developed pattern of major faults; some of the faults probably form part of the boundary of the concealed coalfield. The evidence supports the early hypothesis of Ward (1871) of a northward extension of the coalfield into the Vale of York. — V. S. N.

- 186-408. Pham-Van-Ngoc. Quelques résultats de prospection gravimétrique par mesure directe des dérivées secondes verticales de l'intensité de la pesanteur [Some results of gravimetric prospecting by the direct measurement of the vertical second derivatives of the intensity of gravity]: *Acad. Sci. [Paris] Comptes Rendus.*, v. 252, no. 23, p. 3617-3619, 1961.

The method described in a previous paper (see *Geophys. Abs.* 185-307) was applied to two examples of gravity prospecting in France, one in the southern part of the Lacq oilfield and the other in the Poitou-Gabrielle mining area in Vendée. In the first area, the second derivative method gave results that were in satisfactory agreement with seismic results, in spite of complexities of topography and structure. In one place, flanked on the east and west by areas in which the seismic isobaths showed the top of the Cretaceous at depths of the order of 1,500-1,800 m, the second derivatives showed a narrow, abrupt, uplifted zone; this was confirmed by a boring that reached the Cretaceous at less than 718 m.

In the second area, the contact between granite and highly altered schists, marked by a silicified breccia about 8 m thick, was known from exploratory drilling. The second derivative survey, with a spacing of 25 m between the central station and the marginal stations, reflected the density contrast at the contact clearly with a small positive anomaly above the breccia as well. — D. B. V.

- 186-409. Dimitrov, Lyuben V., Dobrev, Toma B., and Pishchyalov, Stayko St. Izyasnyavane nyakoi elementy na d'lbochinniya tektonski stroeyzh na Sofiyskata kotlovina v'z osnova na geofizichny danny [Determination of some elements of the deep structure of the Sofia depression on the basis of geophysical data]: *Minno-Geol. Inst. Godishnik*, v. 6, pts. 1 and 2, p. 285-318, 1959-1960.

General information is presented on a geological-geophysical study of the Sofia depression and on the interpretation of gravimetric data. The map of the total gravity field was used for preparation of a map of the second vertical derivative of gravity potential according to Veselov's method. Seven geological-geophysical profiles were made from gravity and drilling data. The profiles intersect different parts of the depression and furnish data on structural geologic variations in both vertical and horizontal directions. As a result of these investigations a number of new tectonic lines in the south and southwest parts of the depression were discovered. The depression is bounded by a fault which extends into the basement. — A. J. S.

- 186-410. Kuznetsov, A. A., and Tavrin, I. F. Nekotoryye dannyye o tektonicheskom stroenii zelenokamnogo sinklinoriya na vostochnom sklone yuzhnogo Urala po rezul'tatam gravimetrovykh i magnitnykh s'yemok [Some data on the tectonic structure of the greenstone synclinorium on the east flank of the southern Urals according to results of gravity and magnetic surveys]: Akad. Nauk SSSR Ural. Filial, Gorno-Geol. Inst. Trudy, no. 34, p. 73-81, 1958.

Gravity and magnetic observations were made along a traverse across the greenstone synclinorium of the Bashkir A. S. S. R., and a new interpretation of the geology is made on a basis of these measurements. A deep fault separates the Ural-Tau anticlinorium on the west from the greenstone synclinorium; this zone is marked by positive magnetic and negative gravity anomalies, which are caused by serpentines. A large gravity anomaly corresponding to basic extrusives is recorded in the Irendyk subzone of the synclinorium. Large positive magnetic and gravity anomalies are located in the area east of the Ural River; these are probably due to basic extrusives. A magnetic map and a combined gravity and magnetic profile are given. — J. W. C.

Tanaka, Akiyoshi, and Ninagawa, Shinji, Geophysical prospecting in the eastern part of Kushiro City, Hokkaido. See Geophys. Abs. 186-591.

- 186-411. McDougal, I., and Stott, P. M. Gravity and magnetic observations in the Red Hill area, Southern Tasmania: Royal Soc. Tasmania Papers and Proc., v. 95, p. 7-15, 1961.

The results of reconnaissance gravity and magnetic traverses in the Red Hill area of Tasmania confirm the structure assumed from geological evidence. The gravity measurements proved to be most useful in delineating the structural problems in this area of dolerite intrusions. The Red Hill dike formed by differentiation of dolerite in place, but it does not seem to extend much beyond 600 m below the surface. The magnetic observations, on the other hand, are not particularly useful beyond determining the boundaries of dolerite intrusions hidden below soil or thin sedimentary cover. — V. S. N.

HEAT AND HEAT FLOW

- 186-412. MacDonald, Gordon J. F. Surface heat flow from a differentiated earth: Jour. Geophys. Research, v. 66, no. 8, p. 2489-2493, 1961.

The surface heat flow in model earths has been calculated numerically. The bulk radioactivity of the earth is assumed to be equal to that of chondritic meteorites, and the initial temperature to reach 2,600°C at 1,200 km. For a model in which the radioactivity is uniformly distributed in the outer 600 km the heat flow is 90 ergs per cm² per sec; if the radioactivity is concentrated in the outer 100 km, the present-day surface heat flow is 68 ergs per cm² per sec. Initial heat contributes about 1/5 of the surface heat flow.

The results suggest that a high initial temperature can be ruled out if the hypothesis of a chondritic composition is maintained and if heat is transferred primarily by conduction coupled with radiation; alternatively, a radioactivity lower by a factor of 2 (that is, the mantle alone is chondritic) would permit chondritic models with initially high temperatures. Clark's results (see Geophys. Abs. 185-329) and those of the present paper imply that a chondritic model requires near-surface concentration of heat sources at a temperature well below the melting temperatures. — D. B. V.

- 186-413. Jacobs, J. A. Some aspects of the thermal history of the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 267-275, 1961.

A number of thermal problems connected with the earth are discussed—the early thermal history of the earth and some of its consequences, the formation and state of the inner core, convection in the core and its relation to the earth's magnetic field, and conditions in the upper mantle. — Author's summary

- 186-414. Verhoogen, John. Heat balance of the earth's core: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 276-281, 1961.

It is shown that the heat necessary to maintain convection in the core may come from slow cooling and crystallization of the core with corresponding growth of the solid inner core. The present rate of cooling would be of the order of 10^{-4} – 45° per 10^9 yr, depending on temperature. — Author's summary

- 186-415. Rikitake, Tsuneji, and Horai, Ki-iti. Studies of the thermal state of the earth. The fourth paper: Terrestrial heat flows related to possible geophysical events: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 403-419, 1960.

A subcrustal convection current having a linear dimension of a few thousand km can account for the high heat flow observed on the East Pacific Rise, if the current velocity and temperature gradient in the mantle are several cm per yr and 1°C per km, respectively. A long-lived magma with high temperature and a phase transformation layer can account for only a fraction of the average world heat flow for conceivable cases; therefore, it is difficult to interpret heat flow anomalies alone in terms of geophysical events inside the earth. — D. B. V.

- 186-416. Simmons, Gene. Anisotropic thermal conductivity: Jour. Geophys. Research, v. 66, no. 7, p. 2269-2270, 1961.

It is shown that the use of a point source and the measurement of the thermal gradient to determine thermal conductivity (K) in material with two different principal conductivities (such as shales, slates, and some sandstones) requires two nonparallel holes. As several diamond drillholes are often drilled in different directions from the same location in the mining industry, it would appear that these offer possibilities for useful measurements. The conductivity determined by means of a line source parallel to the z -axis is the geometric mean of the other two principal conductivities. It should be emphasized that this applies to all probe methods, inasmuch as the users of probes seem to neglect the possibility of anisotropy. In particular, if $K_x = K_y \neq K_z$, measurements along z will give only the conductivity in the perpendicular direction.

The main conclusion of this note is that the conductivity determined in place in a single borehole through anisotropic material is not the conductivity parallel to the borehole. — D. B. V.

- 186-417. Kraskovskiy, S. A. O teplovom pole shchitov [On the thermal field of shields]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 387-392, 1961.

The heat flow of the crust was investigated on the basis of data on the principal structural elements of the earth with particular attention given to the

shields. The African, Hindustan, Baltic, Ukrainian, Canadian, and Indian shields were studied. The Spicer tables of geothermal gradients and heat fluxes (see *Geophys. Abs.* 110-6657) were used; these disclosed low geothermal gradients and low values of the heat flow as general characteristics of the thermal fields of the shields. The mean geothermal gradient of the shields is 1.2°C per 100 m, and the mean heat flux is 0.87×10^{-6} cal per cm^2 . These values are explained mainly by the high thermal conductivity of the rocks of the shields. Measurements of the thermal field of the shields hold great promise for elucidating the normal geothermal gradient and the normal heat flux of the earth. — A. J. S.

- 186-418. Reitzel, John. Some heat-flow measurements in the North Atlantic: *Jour. Geophys. Research*, v. 66, no. 7, p. 2267-2268, 1961.

Four measurements of heat flow through the sea bottom were made during the passage of the R. V. Chain from Bermuda to Helsinki in July 1960; results are tabulated. Values for three stations where the bottom had little relief range from 1.20 to 1.54×10^{-6} cal per cm^2 sec, whereas the value at the fourth station, on the Mid-Atlantic Ridge, is $>6.2 \times 10^{-6}$ cal per cm^2 sec. The high heat flow here is comparable to that observed by Bullard, as reported by Hill (see *Geophys. Abs.* 182-524). A pipe dredge haul near the station brought up yellow mud with shards of fresh volcanic glass; evidently the excessive heat flow here is accompanied by volcanism of Pleistocene or Recent date. — D. B. V.

- 186-419. Bullard, E. C., and Day, A. The flow of heat through the floor of the Atlantic Ocean: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 282-292, 1961.

Fifteen heat flow measurements have been made in the Atlantic and one in the Mediterranean. Heat flow is 6.5μ cal per cm^2 sec in the central valley of the Mid-Atlantic Ridge; similarly high values have been found on the crest of the East Pacific Rise. The possibility that these values represent the rising limb of a convection current is discussed. The mean of the remaining 15 values and 5 from a previous investigation is $1.06 \pm 0.55 \mu$ cal per cm^2 sec, close to the mean for the Pacific measurements excluding those on the East Pacific Rise.

The equipment has been modified to determine temperature gradients in the whole probe and in its lower half separately. The lower half gives a value 8.8 percent higher than that for the whole; the reason for this is not clear.

The thermal resistivity (R) of ocean sediments is found to be a linear function of the water content (w , in percent of wet weight). At the temperature of the ocean floor the relation is $R(\text{cm sec}^{\circ}\text{C}/\text{cal}) = (168 \pm 14) + (6.78 \pm 0.31)w$. — D. B. V.

- 186-420. Olivero, Sergio, and Penta, Francesco. Sulle misure di temperatura nel traforo del Monte Bianco [On temperature measurements in the Mont Blanc tunnel]: *Accad. Naz. Lincei Atti, Cl. Sci. Fis., Mat. e Nat. Rend.*, v. 26, no. 6, p. 731-737, 1959.

The program of investigations to be carried on during the tunneling through Mont Blanc will include measurement of temperatures for comparison with theoretical values of the geothermal gradient in mountainous relief. The chief difficulties of such an investigation are of two types: one involves the temporary effect of the installation of the instruments on the original thermal state of the rocks adjacent to the point of measurement, and the other, much more relevant, involves the permanent effect of the tunnel on the thermal regime

inside the mountain. These difficulties are discussed and illustrated by graphs of data obtained in other tunnels. — D. B. V.

- 186-421. Pokrovskiy, V. A. O termal'nykh vodakh Evropeyskoy chasti SSSR [Thermal waters of the European part of the U. S. S. R.]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 99-103, 1960.

The geothermal regimen of the European part of the U. S. S. R. was studied on the basis of more than 4,500 thermograms and 700 individual measurements of temperature on more than 5,000 deep wells. On the basis of these data a geothermal regionalization was accomplished wherein three geothermal provinces are distinguished: areas of depressed temperature (below 20°C at 1,000 m depth), areas of medium temperature (20°C-30°C at 1,000 m depth), and areas of elevated temperature (greater than 30°C at 1,000 m depth). The province of depressed temperature includes the crystalline shields and areas of projections on the basement within the Russian platform. The medium temperature province comprises the rest of the Russian platform where the crystalline basement occurs under a cover of Paleozoic and Mesozoic sediments. The province of elevated temperature includes the Mesozoic downwarps and depressions with a folded metamorphic basement of Paleozoic deposits and thick covering formations in which argillaceous facies predominate. — J. W. C.

- 186-422. Titova, Ye. A. Termal'nyye usloviya Sochi-Matsestinskogo artzianskogo basseyna [Thermal conditions of the Sochi-Matsesta artesian basin]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 110-119, 1960.

A study was made of the geothermal regimen in the Sochi-Matsesta artesian basin, which is located just northeast of the Black Sea between Sochi and Adler in Krasnodar Territory. The search for thermal waters for balneological purposes was a motivating factor in this investigation. Isothermal lines on the top of the Upper Cretaceous are plotted on a map; these show a pronounced high along the Mzymta River to the northeast of Adler. — J. W. C.

- 186-423. Lyubimova, Ye. A., Lyusova, L. N., Firsov, F. V., Starikova, G. N., and Shushpanov, A. P. Opredeleniye poverkhnostnogo teplovogo potoka v Staroy Matseste [Determination of surface heat flux at Staraya Matsesta]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1806-1811, 1960.

None of the large number of temperature measurements taken in deep boreholes of the U. S. S. R. can be used for determination of the surface heat flux because data on the thermal conductivities of the core samples taken from these boreholes are lacking. This paper reports on temperature measurements in 20 boreholes 400 to 2,600 m deep in the Caucasus, which remained idle for 8-10 months before the measurements were made. A resistance thermometer permitted an accuracy of 0.01°C. The instruments and equipment for the temperature measurements and for determination of the thermal constants are described. Data are given for a borehole at Staraya Matsesta (Caucasus); these values are identical with measurements made in 1955 and 1957. The heat flux is 0.82×10^{-6} cal per cm^2 per sec, which is low compared with the generally accepted mean value of 1.2×10^{-6} . The difference may be due to a cooling effect by the Black Sea, but more probably it arises because the horizontal component of the flux did not enter in the data. — A. J. S.

- 186-424. Dzhibuti, S. S. Nekotoryye dannyye po geotermii Zapadno-Turkmenskogo artezianskogo basseyna [Some data on the geothermy of the west Turkmen artesian basin]: Akad. Nauk SSSR Lab. Gidrogeol. Problem, Trudy 30, p. 104-109, 1960.

A provisional attempt is made at synthesizing the available geothermal data for the west Turkmen artesian basin, which lies to the east of the south part of the Caspian Sea. A characteristic feature of the ground water regimen of this basin is its elevated temperature, which in natural springs ranges from 35°C to 68°C and in individual oil wells reaches 100°C. The geothermal gradient is listed in a table for 33 boreholes in the Cheleken area, 17 in the Nebit-Dag area, and one each for 7 other areas. On the basis of these measurements it is concluded that temperatures of 55°C-60°C are present regionally at depths of 1,000 m, 80°C-82°C at 2,000-3,000 m, and 100°C at 3,500-4,500 m. —J. W. C.

- 186-425. Cheremenskiy, G. A. Vliyaniye skladchatogo fundamenta na teplovoye sostoyaniye mezokaynozoysskikh otlozheniy Zapadno-Sibirskoy nizmennosti [The effect of folded basement on the thermal state of Meso-Cenozoic sediments of the West Siberian Lowland: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 705-709, 1961.

The correlation between the thermal state of the crust and the tectonic, lithologic, hydrologic, and other factors of the West Siberian Lowland is discussed. From the geothermal profile along the Kuznetsovo-Slavgorod traverse it was found that the position of isothermal surfaces over the basement of the lowland depends basically on the ratio of the thermal conductivities of the basement rock to those of the covering sedimentary units. An increase of geothermal gradient in the peripheral parts of the West Siberian Lowland and in regions of uplift of the basement is due largely to the thermal anisotropy of the Meso-Cenozoic rocks. —A. J. S.

- 186-426. Cheremenskiy, G. A. O vremeni vosstanovleniya termicheskogo rezhima, narushennogo bureniyem skvazhiny [On the stabilization time of the thermal regimen disturbed by drilling of a borehole]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 12, p. 1801-1805, 1960.

The time required for a drill hole to reestablish its thermal equilibrium after drilling was investigated. Temperature measurements were made at a depth of 1,400 m in a borehole in the Kolpashevo region of the West Siberian Lowland. Readings at 0.5, 20, and 50 days after drilling gave $t=13.5^{\circ}\text{C}$, 42°C , and 46°C , respectively. The hydrologic temperature for the stratum at a depth of 1,400 m is 64°C . A comparison is made with the cooling rate of a borehole drilled in permafrost in Alaska. (See also Geophys. Abs. 184-418).—A. J. S.

- 186-427. Uyeda, Seiya, and Horai, Ki-iti. Studies of the thermal state of the earth. The sixth paper: Terrestrial heat flow at Innai oilfield, Akita Prefecture and at three localities in Kanto District, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 421-436, 1960.

Terrestrial heat flow has been determined at four places in Honshu, Japan, in deep wells penetrating water-saturated sediments. The values obtained are as follows (in 10^{-6} cal per cm^2 per sec): 1.49 at Innai oilfield in Akita Prefecture; 0.74 at Tokyo University; and 0.76 at Kashima and 0.91 at Katsuta, both in Ibaraki Prefecture.

The data so far obtained suggest that in eastern Japan heat flow is less on the Pacific coast side than inland and on the Japan Sea side. Repeated measurements at Kashima and Katsuta showed that temperatures measured immediately after drilling were reliable only near the bottom of the hole. — D. B. V.

- 186-428. Horai, Ki-iti. Studies of the thermal state of the earth. The third paper: Terrestrial heat flow at Hitachi, Ibaraki Prefecture, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 571-592, 1959.

Geothermal gradients, measured at 68 places in drifts in the Hitachi copper mine, were found to range from $0.94 \times 10^{-2} \text{ } ^\circ\text{C}$ per m in the northern part of the mine to $1.21 \times 10^{-2} \text{ } ^\circ\text{C}$ per m in the southern part. The apparent thermal conductivities of 36 rock specimens from various parts of the mine were measured by the divided-bar method and found to be $6.73\text{--}7.08 \times 10^{-3}$ cal per cm sec $^\circ\text{C}$ and $6.50\text{--}7.43 \times 10^{-3}$ cal per cm sec $^\circ\text{C}$ in the two parts of the mine, respectively. From these values the terrestrial heat flow was computed to be $0.63\text{--}0.67 \times 10^{-6}$ cal per cm^2sec for the northern part and $0.78\text{--}0.90 \times 10^{-6}$ cal per cm^2sec for the southern part. These values are slightly smaller than those already known in Japan; whether this is a local anomaly or is due to some large-scale phenomenon, such as convection in the mantle, is not clear at present. — D. B. V.

INTERNAL CONSTITUTION OF THE EARTH

- 186-429. Wegmann, E. Wege in die Tiefen [Paths to the depths (with English summary p. 701)]: Geol. Rundschau, v. 50, p. 84-93, 1960.

All interpretations of the nature of the earth's deep crust are based on principles and concepts used for the exposed parts of the crust. The deep crust probably consists of different kinds of materials whose modes of behavior overlap from our present perspective, leading to the great diversity of concepts concerning its nature. — D. B. V.

- 186-430. Howell, B[enjamin] F., Jr., and Woodtli, R. A. Factors influencing thickness of the earth's crust: Jour. Geophys. Research, v. 66, no. 8, p. 2601-2605, 1961.

If the M-discontinuity is due primarily to a phase change, its depth should vary with surface temperature. It is calculated that 12.5° change in surface temperature would be required to cause a 1-km change in depth of the M-discontinuity. Present methods at best are barely adequate for measuring crustal thickness to this accuracy; therefore, the effect of temperature on crustal thickness, if it exists, might readily have been overlooked in crustal-thickness studies.

To test this hypothesis, 21 measurements of continental crustal thickness were selected from the literature and tested for a correlation of thickness with surface temperature; the results showed no evidence of any dependence of crustal thickness on temperature. A correlation of crustal thickness with surface elevation, based on the isostatic concept, is too low (correlation coefficient 18.5 percent) to be significant. A third correlation not based on any theory explaining crustal thickness was also made, in which crustal thickness was plotted against distance from the nearest edge of the continental shelf; for a linear plot the coefficient of correlation was 23.5 percent and for a semi-logarithmic plot 43.8 percent. The pooriness of all three correlations shows that no one of these factors alone is responsible for crustal thickness. One

other conclusion drawn from this study is that accurate determinations of crustal thickness are needed, preferably point-by-point determinations rather than single figures for whole profiles. — D. B. V.

- 186-431. Steinhart, J. S., and Meyer, R. P. (with contributions by Woollard, G. P., Bonini, W. E., and Smith, T. J.). Explosion studies of continental structure: Carnegie Inst. Washington Pub. 622, 409 p., 1961.

Crustal studies from observations of seismic waves generated by explosions are reported for five areas in North America selected for their gravity anomalies and tectonic associations: Mexico—high plateau with large negative Bouguer gravity anomaly; Arkansas—slightly positive craton with positive Bouguer anomalies; Wisconsin—shield area with both positive and negative Bouguer anomalies; eastern Montana—margin of a mountain system with large negative Bouguer anomalies; and the Rocky Mountains of western Montana. The past history of explosion studies; the theoretical background; the methods of data reduction, model selection, and statistical analyses; and instrumentation and field problems are discussed in five chapters. Data from each area are treated in separate chapters, and results are illustrated in tables and cross sections. A final chapter summarizes seismic evidence concerning continental crustal structure and includes a table with data for Europe, central Asia, southern Africa, Australia-New Zealand, South America, Iceland, and North America.

General conclusions are as follows: (1) The near surface velocity structure cannot be ignored without expecting errors in calculated values of crustal thickness. (2) The method of computation used in obtaining crustal thickness is important in minimizing the type of errors usually present. The crossover distance method is recommended for unreversed profiles. (3) A minimum estimate of statistical uncertainty may be obtained by straight-forward statistical techniques. (4) Difficulties in the use of absolute amplitude data because of variable response of the ground-geophone system may be eliminated by the use of amplitude ratios. (5) A velocity gradient is present near the surface of the earth due in part to pressure increase, which affects the shape of seismic traveltime graphs. (6) A velocity increase within the crust is required by the data; it is not clear whether this increase is continuous or discontinuous. (7) Mean velocities in the crust (and presumably densities) vary from place to place. (8) No single variable can be used to predict crustal structure; the mean crustal velocity and the Bouguer anomalies together offer the most promise as a linear predictor, and there is some indication that geologically corrected isostatic anomalies can be used also. (9) Isostasy is realized, at least on a regional basis, but Pratt type compensation may be more important in some places than Airy type. This implies, and the results show, that high elevations do not always mean a thick crust and low elevations are not always associated with a thin crust. — V. S. N.

Cameron, J. B. Earthquakes in the northern California coastal region (pt. 1). See Geophys. Abs. 186-135.

Milne, W. G., and White, W. R. H. A seismic survey in the vicinity of Vancouver Island, British Columbia. See Geophys. Abs. 186-587.

- 186-432. Gaskell, T[homas] F., Hill, M[aurice] N[eville], and Swallow, J. C. Seismic measurements made by H. M. S. Challenger in the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea, 1950-53: Royal Soc. London Philos. Trans., ser. A, v. 251, no. 988, p. 28-83, 1958.

The seismic experiments made during the "Challenger" oceanographic cruises of 1950-52 (around-the-world) and 1953 (northeastern Atlantic Ocean) are described. Details of the methods used (refraction and some reflection) are given, and methods of analyzing the refracted wave arrivals observed in deep water experiments are discussed in full.

The results of structural interpretation of the measurements are discussed and presented in diagrams showing crustal sections in many parts of the North Atlantic, Pacific, and Indian Oceans. — D. B. V.

Hochstrasser, Urs, and Stoneley, Robert [S.]. The transmission of Rayleigh waves across an ocean floor with two surface layers, pt. 2: Numerical. See *Geophys. Abs.* 186-197.

Reich, H[ermann]. On the problem of the geologic interpretation of seismic discontinuities in the Alps. See *Geophys. Abs.* 186-588.

186-433. Shechkov, B. N. Stroyeniye zemnoy kory v Yevrazii po dispersii poverkhnostnykh voln [Structure of the crust in Eurasia according to dispersion of surface waves]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 694-699, 1961.

The average thickness of the crust in Eurasia is determined theoretically from the dispersion of Love and Rayleigh waves. The thicknesses of the granite and basalt layers are studied on a two-layer model, the lower layer being placed over an elastic half space. The theoretical values determined for Love and Rayleigh waves were found to agree. The results obtained were checked against the data of observations along the traverses Central Asia-Kurile Islands and European U.S.S.R. - East China Sea - Japan and found to compare favorably (see also *Geophys. Abs.* 166-90, 176-79). — A. J. S.

186-434. Val'dner, N. G., and Savarenskiy, Ye. F. Po povodu prirody volny Lg_1 i yeye rasprostraneniya v Severo-Vostochnoy Azii [In regard to the nature of the Lg_1 wave and its propagation in northeast Asia]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 1, p. 3-24, 1961.

The recently discovered seismic waves Lg and Rg serve as a proof of continuity of the upper granitic layer in the crust in the area of propagation of these waves. The Lg_1 wave is interpreted as an overtone of the Love wave. — A. J. S.

Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismic investigations of the earth's crust in the Bukhara area of the Uzbek SSR. See *Geophys. Abs.* 186-589.

Kosminskaya, I. P., and Krakshina, R. M. The transcritical reflections from the Mohorovičić discontinuity. See *Geophys. Abs.* 186-590.

186-435. Mikumo, Takeshi, and Otsuka, Michio. Seismic studies on the crustal structure in the Wakayama district [in Japanese with English abstract]: *Zisin*, ser. 2, v. 13, no. 4, p. 199-209, 1960. Mikumo, Takeshi. Crustal structure in Wakayama district as deduced from local and near earthquake observations [English version]: *Kyoto Univ. Disaster Prevention Research Inst. Bull.*, no. 39, 25 p., 1960.

From observation of the records of near and local earthquakes in the Wakayama district, Japan, the P- and S-wave velocities and thickness of the crustal layers in the area were determined.

For the sedimentary layer $V_p=4.3$ kmps, $V_s=2.4$ kmps, $h_1=4$ km; for the granitic layer $V_p=5.5$ kmps, $V_s=3.2$ kmps, $h_2=7$ km; for the basaltic layer $V_p=6.1$ kmps, $V_s=3.5$ kmps, $h_3=15$ km; and for the mantle surface $V_p=8.0$ kmps, $V_s=4.5$ kmps. The depth to the M-discontinuity is estimated to be about 26 km. The focuses of microearthquakes in the northern part of the district are distributed above the granitic layer. — V. S. N.

- 186-436. Mumme, I. A. Determination of the crustal thickness of the earth in the general region of Adelaide, South Australia: Royal Soc. South Australia Trans., v. 84, p. 61-62, 1961.

Crustal thickness in the region of Adelaide, Australia, has been determined from the average of many absolute gravity stations in the area to be 33 km. This figure is an average of the results obtained by six different methods of calculation—Andreyev's equation, Woollard's elevation, Woollard's gravity, Russian and Chinese gravity equation, Russian and Chinese elevation equation, and Heiskanen and Vening Meinesz' equation. — V. S. N.

- 186-437. Lazarev, G. Ye., and Ushakov, S. A. Zemnaya kora Antarktidy [The earth's crust in Antarctica]: Priroda, no. 12, p. 17-22, 1960.

On the basis of Bouguer anomalies the earth's crust in eastern Antarctica is divided into three sectors: (1) the Davis Sea sector, which is a continental slope; (2) the 100 km offshore zone of the Davis Sea and the zone 50 km from Mirnyy to Pionerskaya, which form the continental shelf; and (3) the zone of the platform depressions and low plateau 950 km farther inland to Komsomol'skaya. The thickness of the crust in these zones is 32, 37, and 40 km, respectively. — A. J. S.

- Kogan, S. D., Pasechnik, I. P., and Sultanov, D. D. Seismic observations in Antarctica. See Geophys. Abs. 186-153.

International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha. See Geophys. Abs. 186-602.

- 186-438. Shutt, T. C. Primary magma: Univ. Sheffield Geol. Soc. Jour., v. 4, no. 2, p. 13-17, 1961.

It is suggested that there is one primary magma whose composition varies from basic to silicic according to the layer of the crust involved in the melting. Magmas are formed locally through heating by radioactivity or, preferably, through release of pressure (as in orogenic periods), and the rocks intruded from the magma reflect the environment of melting as opposed to any stage of differentiation or any degree of mixing. — V. S. N.

- 186-439. Kennedy, George C. Phase relations of some rocks and minerals at high temperatures and high pressures, in *Advances in Geophysics*, v. 7: New York and London, Academic Press, p. 303-322, 1961.

This is a longer version of the paper published in *Am. Geophys. Union Trans.*, v. 41, no. 2, p. 283-286, 1960 (see Geophys. Abs. 182-342). — V. S. N.

- Jobert, Nelly. Approximate calculation of the period of the spheroidal oscillations of the earth. See Geophys. Abs. 186-187.

- 186-440. Gaskell, T[homas] F. The Mohole project, in *Science Survey 1*: New York, MacMillan Co., p. 279-289, 1960.

A popular account is given of the development of the idea to drill to the M-discontinuity, of the technical problems to be solved, and of the type of tools needed to accomplish the project. — V. S. N.

- 186-441. Wetherill, G[eorge] W. Steady-state calculations bearing on geological implications of a phase-transition Mohorovicic discontinuity: *Jour. Geophys. Research*, v. 66, no. 9, p. 2983-2993, 1961.

The steady-state approximation is used to calculate the temperature as a function of depth within the crust for different models, assuming that the lower boundary of the crust is a phase transition, and the depth of this transition is calculated for several typical transitions. Phase transitions that have been observed in the laboratory can be fitted with depths of the continental M-discontinuity, but it is difficult to obtain reasonable oceanic crustal thicknesses using the same phase transition. These calculations indicate that: (1) If the M-discontinuity results from a phase transition similar to albite+nepheline \rightarrow jadeite, the continental crust should have had an average elevation of more than 4 km about 2,000 million years ago; (2) an increase by a factor of 1.25 in the continental heat flow can result in appreciable changes in elevation; (3) it is difficult to reconcile the absence of greater elevation and crustal thickening in the area of high heat flow in the southeastern Pacific Ocean with the phase-change hypothesis; and (4) the mechanism of mountain building discussed by Kennedy (see *Geophys. Abs.* 179-187) and by MacDonald and Ness (see *Geophys. Abs.* 182-358) can produce appreciable crustal elevations if the time is sufficiently long. — D. B. V.

- 186-442. Hoffman, John P., Berg, Joseph W., Jr., and Cook, Kenneth L. Discontinuities in the earth's upper mantle as indicated by reflected seismic energy: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 17-27, 1961.

Thirty-three seismograms from 9 large quarry blasts (50,000-2,138,000 lb of explosives detonated at Promontory and Lakeside, Utah) obtained at 10 stations between 76 and 1,009 km from the blasts were analyzed for possible reflections from inhomogeneities in the earth's upper mantle. Arrivals having apparent velocities that could correspond to reflections from discontinuities at depths of about 190, 520, and 910 km in the mantle are reported. These depths were computed using average velocities based on velocity-depth curves given by Jeffreys and Gutenberg for the deeper portions of the upper mantle and assuming that linear ray paths pertained. More confidence is placed in the results that indicate a discontinuity at 190 km than in those indicating the discontinuities at 520 and 910 km. — D. B. V.

- 186-443. Lehmann, I[ngel]. S and the structure of the upper mantle: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 124-138, 1961.

The European as well as the northeastern American observations of S at small epicentral distances indicate the presence of a low velocity layer. In Europe its upper boundary seems to be at a depth of about 140 km. Since late S phases are observed at epicentral distances down to about 10° there is likely to be an abrupt increase of velocity (as well as of velocity gradient) at the lower boundary of the layer at about 220 km depth. Late S phases beyond 20° can be accounted for if a further strong increase of velocity gradient at a greater depth is assumed. — Author's abstract

- 186-444. Rosenfeld, John L., and Chase, Armond B. Pressure and temperature of crystallization from elastic effects around solid inclusions in minerals: *Am. Jour. Sci.*, v. 259, no. 7, p. 519-541, 1961.

A new physical method for determination of the pressure-temperature conditions for crystallization of minerals deep within the earth is proposed. Earth processes commonly result in the transfer of a mineral grain from the pressure-temperature (P, T) condition of its origin to considerably different P-T conditions. If a mineral grain includes a grain of another mineral, transfer to new P-T conditions commonly will cause anisotropic elastic strain effects around the inclusion owing to different coefficients of thermal expansion and compressibility for the two minerals. To the extent that these elastic effects remain reversible over geologic time intervals, they represent stored information concerning the pressure and temperature of origin. The differential equation for the P-T curve representing absence of anisotropic stress around an inclusion of one isometric crystal (also a homogeneous fluid) inside of another isometric crystal is given. Experimental determination of two such P-T curves for a given host containing two different kinds of inclusions, known to be contemporaneous, would result in an intersection representing the pressure and temperature of origin. Suggested techniques for determination of P-T curves are discussed.

Natural examples of stress effects around inclusions in diamond and associated pyrope are consistent with extrapolations based on known values of α and β and inferred P-T conditions within the earth. Examination of these minerals, having a probably origin in the mantle but now included in the kimberlites, should allow determination of specific temperatures at specific pressures equivalent to depths within the mantle of the order of 100 miles or more. — V. S. N.

- 186-445. Egyed, L[ászló]. On the origin and constitution of the upper part of the earth's mantle: *Geol. Rundschau*, v. 50, p. 251-258, 1960.

Using the Dirac-Gilbert equation as a basis for the expansion theory (see *Geophys. Abs.* 182-59, -281), it is shown that the earth's mantle, except in the uppermost 200 km, must be similar in composition to a volatile-rich magma of intermediate composition. Density does not increase uniformly with depth; rather, it has a slight maximum between 50 and 100 km and a slight minimum below this. The low-velocity channel is due to changes in composition rather than to thermal effects. The hydrosphere and most of the atmosphere must have been formed at the same time as the crust, in the first stages of the earth's evolution. The evolution of the moon's surface closely parallels that of the earth's mantle. — D. B. V.

- 186-446. Magnitskiy, V. A. Obolochka i kora zemli [Mantle and crust of the earth]: *Sovetskaya Geologiya*, no. 5, p. 3-15, 1961.

On the basis of geophysical data and the composition of meteorites, the suggestion is made that the mantle was originally close to eclogite in composition. The existence now of two types of crust (continental and oceanic) gives a basis for supposing that they are due to different courses of development of material of the mantle. The difference between the continental and oceanic types of crust depends either on a heterogeneity of the original composition of the mantle or on a difference in heating rates in different parts of the mantle. Models of formation of a continental type crust from the mantle are given. — J. W. C.

- 86-447.** Wada, Tatsuhiko. On the physical properties within the B-layer deduced from olivine-model and on the possibility of polymorphic transition from olivine to spinel at the 20° discontinuity: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 37, 18 p., 1960.

An equation of state of forsterite based upon an ionic model is deduced theoretically. Calculated variations of density and incompressibility with pressure agree with those of Bullen for the B-layer. The activation energy of forsterite, having Schottky defects, is evaluated at 3.29 eV (e =charge at definite point on crystal lattice, v =volume per ion-pair of Mg^{+2} and O^{-2}). The variation of activation energy with pressure is investigated, and it is shown that extrapolation from experimental values obtained within 10,000 bars is not reliable. Temperature distribution obtained within the B-layer is in accordance with Gutenberg's. Comparison of the lattice energies of olivine and spinel shows that the polymorphic transition from olivine to spinel is impossible although this problem is still open to question because even if the lattice energies of both phases is well evaluated the difference may not be reliable. — V. S. N.

- 186-448.** Wada, Tatsuhiko. On origins of the region C and the core of the earth—Ionic-intermetallic-metallic transition hypothesis: Kyoto Univ. Disaster Prevention Research Inst. Bull. no. 38, 64 p., 1960.

A model of the interior of the earth based on modern solid-state physics is presented. The B region is considered to be mainly olivine with ionic bonding. The C region (olivine changing to periclase and coesite) is regarded as an area of transition from the ionic to the intermetallic state of MgO. The transition is due to pressure increase and is characterized by a gradual change in compressibility and density corresponding to a gradual increase of homopolar character in bonding in the originally ionic MgO crystals. The gradual increase in homopolar character results in a decrease in the energy gap of MgO and, consequently, in an increase of electrical conductivity in the C area that is compatible with geomagnetic data. The D region is composed completely of intermetallic MgO (mainly periclase with sphalerite structure) with covalent bonding, and the core is composed of metallic MgO (mainly periclase) with semimetallic bonding that becomes metallic in the liquid phase. This model with an intermetallic transitional layer makes the possibility of a metallic core more reasonable. — V. S. N.

Rikitake, Tsuneji. The anomalous behavior of geomagnetic variations of short period in Japan and its relation to the subterranean structure. The 9th report. See Geophys. Abs. 186-488.

- 186-449.** Ringwood, A. E. Silicon in the metal phase of enstatite chondrites and some geochemical implications: Geochim. et Cosmochim. Acta, v. 25, no. 1, p. 1-13, 1961.

Using X-ray and chemical methods, it has been established that 2-6 atomic percent of silicon occurs in solid solution in the metal phases of all of 8 enstatite chondrites that were examined. No silicon was found in the metal phase of ordinary chondrites. The significance of these data to the hypothesis that the earth's core contains silicon as a major component is discussed in some detail.

Study of the conditions accompanying segregation of the core, both in the earth and in a parent meteoritic body, lead to the conclusion that the core is probably not in chemical equilibrium with the surrounding mantle. One of the

principal effects of this disequilibrium is diffusion of silicon from the core into the adjacent mantle, resulting in reduction of oxidized iron and precipitation of metallic iron. This effect may be responsible for the anomalous seismic velocity gradients in the bottom 200 km of the mantle. Mechanically this region is unstable owing to the tendency of precipitated iron to collect and sink into the core.

Attainment of chemical equilibrium across the core-mantle boundary is accompanied by generation of electric currents. These may be relevant to the origin of the geomagnetic field and may also affect the electromagnetic coupling between core and mantle. — D. B. V.

- 186-450. Lucke, Otto. Über die Abweichungen der Gestalt des Erdkerns von der Kugelgestalt [On the departure of the shape of the earth's core from the spherical (with English summary)]: *Gerlands Beitr. Geophysik*, v. 70, no. 1, p. 1-10, 1961.

Knowledge of the pressure, density, and layering of the earth's interior is based mainly on the interpretation of seismic traveltimes with the assumption that velocity is a function of distance r from the center of the earth. Three maps are presented to prove this hypothesis, showing geoid undulations, geomagnetic non-dipole field anomalies (epoch 1945), and anomalies in the earth's core as revealed by PcP-, ScS-, PcS-, and ScP-wave traveltimes. A significant correlation exists between positive and negative areas in all three. The traveltimes of these waves represent the time it takes to traverse the distance from an earthquake focus to the reflection point T_1 plus the time from there to the station T_2 ; by constructing the surfaces $T_1 + T_2 = \text{const}$ for many earthquakes, information on the surface of the core can be obtained by ascertaining the reflection points as a function of the coordinates of the surface of the core corresponding to a given traveltime. — D. B. V.

- 186-451. Ledersteger, Karl. Die Abplattungsfunktion einparametrischer sphäroidischer Gleichgewichtsfiguren [The flattening function of one-parameter spheroidal equilibrium figures (with English summary)]: *Geofisica Pura e Appl.*, v. 46, p. 1-10, 1960.

As the density law of spheroidal equilibrium figures has been shown to be strictly unambiguous (see *Geophys. Abs.* 184-336, -337), it is possible to obtain from a given equilibrium figure an infinite series of new equilibrium figures of steadily decreasing size and mass by the method of "leaf-stripping." In this way any inner equipotential surface can be revealed and its flattening can be calculated, entirely independently of Clairaut's equation. This method can also be used for equilibrium figures with more than one parameter and discontinuous density distribution. For Wiechert's earth model it yields values of 3,864.75 km for the depth to the core and 17.84 km for the density discontinuity at the core boundary. — D. B. V.

Verhoogen, John. Heat balance of the earth's core. See *Geophys. Abs.* 186-414.

Knopoff, Leon, and Gilbert, Freeman. Diffraction of elastic waves by the core of the earth. See *Geophys. Abs.* 186-241.

ISOSTASY

- 186-452. Lyustikh, E. [Ye.] N. Isostasy and isostatic hypotheses: Washington, D. C., American Geophysical Union, 119 p., 1960.

This is an English translation of the paper previously published in *Akad. Nauk SSSR Geofiz. Inst. Trudy*, no. 38(165), p. 1-90, 1957 (see *Geophys. Abs.* 170-214). — J. W. C.

ISOTOPE GEOLOGY

- 186-453. Mayne, K. I. Stable isotope geochemistry and mass spectrometric analysis, in *Methods in geochemistry*: New York and London, Interscience Publishers Inc., p. 148-201, 1960.

The principles of some of those processes that can lead to isotopic fractionation are described briefly, and the way in which these effects can be observed and interpreted in nature is outlined. The discussion has been limited arbitrarily to stable isotope studies. The following are discussed: physical-chemical isotope fractionations in nature including exchange equilibrium fractionation, that due to differences in vapor pressure, and organic fractionation; radioactivity and the resulting variations in isotope abundances including geochronology and the Rb, K, U, and Pb dating methods, common lead, and induced nuclear effects; mass spectrometric principles and practice including first- and higher-order focusing, fringing field effects, two-stage instruments, ion-beam detectors, ion sources and sample handling, precision isotope difference measurements, and measurement of small samples. Emphasis is placed on principles and methods rather than on experimental results and particular instruments. A list of 71 references is included. — V. S. N.

- 186-454. Webster, R. K. Mass spectrometric isotope dilution analysis, in *Methods in geochemistry*: New York and London, Interscience Publishers Inc., p. 202-246, 1960.

In the method of stable isotope dilution the quantity of an element is estimated from the change produced in its isotopic composition by the addition of a known quantity of a stable isotopic tracer of that element. The use of electromagnetic separators has permitted a rapid expansion of the method, and this type of analysis may be applied now to at least four-fifths of the elements. The following aspects are discussed: production of tracers; the method; chemical treatment of samples; summary of errors; and applications including elemental abundance determination, geological age determination, and investigation of the decay of long-lived radioactive nuclides. The main application of this method is in the field of age determination for measurement of uranium, thorium, rubidium, and potassium ages. A list of 167 references is included. — V. S. N.

- Levskiy, L. K. Inert gases in two iron meteorites. See *Geophys. Abs.* 186-64.

- 186-455. Nakai, Nobuyuki. Carbon isotope fractionation of natural gas in Japan: *Nagoya Univ. Jour. Earth Sci.*, v. 8, no. 2, p. 174-180, 1960.

Carbon isotope ratios, C^{13}/C^{12} , of methane and carbon dioxide, and dissolved carbonate and organic material in connate waters from natural gas fields in Japan have been determined. Methane is enriched in C^{12} , whereas carbon dioxide and carbonate are enriched in C^{13} as compared to source organic material. In the process of natural gas production and methane accumulation, the methane is enriched in C^{12} approximately 7 percent relative to the coexisting carbon dioxide and carbonate. — Author's abstract

- 186-456. Craig, Harmon. Standard for reporting concentrations of deuterium and oxygen-18 in natural waters: *Science*, v. 133, no. 3467, p. 1833-1834, 1961.

A "standard mean ocean water" (SMOW), based on the set of ocean water samples used by Epstein and Mayeda to obtain a reference standard for O^{18} data (see *Geophys. Abs.* 158-185) but defined relative to the National Bureau of Standards isotopic reference water sample, is proposed for reporting both D and O^{18} variations in natural waters relative to the same water.

The total variations in meteoric waters are about 360 per mil for D and about 48 per mil for O^{18} , relative to SMOW. This variation in D content corresponds to a variation of about 6 ppm in density, whereas the O^{18} variation corresponds to about 11 ppm in density. — D. B. V.

- 186-457. Bainbridge, A. E., Sandoval, Paula, and Suess, H[ans] E. Natural tritium measurements by ethane counting: *Science*, v. 134, no. 3478, p. 552-553, 1961.

A method is described for the synthesis of ethane from hydrogen that is at present used for the counting of low-level tritium activity at the La Jolla tritium laboratory. The reaction procedure is simple and involves the mixing of the hydrogen with acetylene over a colloidal palladium catalyst. Counting characteristics of ethane are found to be ideal. With a 1-liter counter filled to three atmospheres of ethane, only a tenfold tritium enrichment is necessary in order to obtain a sensitivity of 0.32 counts per minute per tritium unit. — Authors' abstract

- 186-458. Rama; Koide, M.; and Goldberg, E. D. Lead-210 in natural waters: *Science*, v. 134, no. 3472, p. 98-99, 1961.

The distribution of Pb^{210} , which enters the ocean subsequent to its production in the atmosphere by Rn^{222} decay, shows an increase with depth of sea water. By use of a simplified two-layer model of the ocean, a residence time of lead in the upper mixed layer of less than 2 years is derived. It is suggested that the marine biosphere is responsible for the conveyance of lead from surface to deeper waters. The distribution of Pb^{210} in the Colorado River indicated a rapid removal along the path from its origin in the feed waters to the reservoir at Lake Mead. — Authors' abstract

- 186-459. Chow, Tsaihwa J. Lead isotopes in sea water and marine sediments: *Jour. Marine Research*, v. 17, p. 120-127, 1958; reprinted in *Calif. Inst. Technology Div. Geol. Sci. Contr.*, no. 905, [no date].

The lead concentration obtained from sea water samples of San Juan Channel, Wash., was 0.2μ g per l or less. Leads isolated from Pacific and Atlantic pelagic clay sediments show an isotopic composition similar to that of manganese nodules from the respective oceans. The Pb^{206} content in the Atlantic lead was more abundant than in the Pacific lead. This finding agrees with the postulate that the Atlantic lead was derived from rocks which contained high proportions of old granites and that the Pacific lead was from rocks containing high proportions of relatively young basalts. — Author's abstract

- 186-460. Tugarinov, A. I., Shcherbakova, R. N., and Bedrinov, V. P. Izotopnyy sostav svintsa svintsovykh rudoproyavleniy Pridnestrov'ya [Isotopic composition of lead of the lead manifestations of the

Dniester foreland area (with English abstract)): *Geokhimiya*, no. 4, p. 298-304, 1960.

The lead isotope ratios in galena impregnations and veinlets in sandstones in the Dniester foreland area of the Ukrainian S. S. R. change noticeably with depth from Pb^{206}/Pb^{204} : Pb^{207}/Pb^{204} : $Pb^{208}/Pb^{204}=18.25 : 15.12 : 36.8$ to $24.25 : 17.39 : 44.05$, respectively. This is attributed to metamorphic phenomena consisting of partial solution of feldspar grains in the sandstones with selective leaching of anomalous leads present in the feldspars. — D. B. V.

186-461. Vinogradov, A. P., Tarasov, L. S., and Zykov, S. I. *Izotopnyy sostav svintsov kolchedannykh mestorozhdeniy Urals* [The isotopic composition of leads from pyrite deposits of the Urals (with English abstract)]: *Geokhimiya*, no. 6, p. 475-489, 1960.

The isotopic composition of lead impurities in the pyrite-chalcopyrite ores of the Urals was investigated in order to determine the age relations of the deposits. Results are tabulated. There are three age groups. Most of the ores are post-Lower Carboniferous; older deposits, probably Caledonian, are found on the west flank of the southern Urals; and there are some younger leads with anomalous isotopic composition.

Similarity of isotopic composition suggests that the main Ural deposits were formed in the same manner as the post-Lower Carboniferous ores of the Irtysh zone of the Altay. — D. B. V.

186-462. Vinogradov, A. P., Zykov, S. I., and Tarasov, L. S. *Izotopnyy sostav svintsa-primesi v rudakh i mineralakh kak pokazatel' ikh genezisa i vremeni obrazovaniy* [Isotopic composition of admixtures of lead in ores and minerals as an indication of their origin and of time of formation]: *Geokhimiya*, no. 6, p. 515-523, 1958.

It is shown that the isotopic composition of lead impurities in various non-lead ores can be used as a criterion for their mode of genesis and age. The method is applied to sulfide ores from the Rudnyy Altay; quartz, scheelite, wolframite, and cassiterite from the Kalba-Narym district; quartz and wolframite from the Gornyy Altay; sulfides and platinum from northern Siberia; and sulfides from the Kola Peninsula.

The isotopic composition of lead in cassiterites is anomalous, showing that minerals in which accessory radioactive minerals may be expected are not suitable for this type of genetic and age analysis. The fact, however, that relatively higher temperature cassiterites are richer in impurities, and therefore more anomalous, provides an additional criterion for distinguishing pegmatitic, pneumatolytic-hydrothermal, and hydrothermal types of cassiterite. — D. B. V.

186-463. Benson, Bruce [B.], and Parker, Peter D. M. Nitrogen/argon and nitrogen isotope ratios in aerobic sea water: Deep-Sea Research, v. 7, no. 4, p. 237-253, 1961.

Nitrogen gas concentration in sea water has been assumed to be conservative, that is unaltered by biological and chemical activity. If this is true, one or more physical effects must be responsible for the observed variations in the percentage saturation of nitrogen. The possible physical factors are listed. A surface equilibrium model is proposed, and results are presented to test the model and to ascertain whether or not nitrogen dissolved in sea water is biologically and chemically inert. Argon is used as a reference gas, and the analysis is carried out with a mass spectrometer. It is concluded that

nitrogen is "conservative." There is some evidence that the nitrogen 29/28 relative abundance in the dissolved gas maybe greater than that in the atmosphere by approximately one part in 10,000. — V. S. N.

- 186-464. Richards, Francis A., and Benson, Bruce B. Nitrogen/argon and nitrogen isotope ratios in two anaerobic environments, the Cariaco Trench in the Caribbean Sea and Drømsfjord, Norway: Deep-Sea Research, v. 7, no. 4, p. 254-264, 1961.

Mass spectrometric measurements of nitrogen/argon and nitrogen isotope ratios are used to study the nitrogen arising from decomposition of organic matter in the anaerobic marine environments of the Cariaco Trench in the Caribbean Sea and the Drømsfjord in Norway. Values of N_2/Ar are larger than would be expected from dissolved atmospheric gases. Assuming that the argon concentration is biologically unaffected, the excess quantities of N_2 can be calculated. Results are in good agreement with amounts of nitrogen expected to arise from decomposition of organic matter. It is shown that nitrogen isotope ratios are markedly different in the nitrogen of biogenic origin from those in nitrogen dissolved from the atmosphere; and that free nitrogen can be formed from organic matter only through denitrification of nitrate formed as an intermediate step. — V. S. N.

Eberhardt, P[eter], and Eberhardt, A. Ne in some stone meteorites. See Geophys. Abs. 186-62.

- 186-465. Lowenstam, Heinz A. Mineralogy, O^{18}/O^{16} ratios, and strontium and magnesium contents of recent and fossil brachiopods and their bearing on the history of the oceans: Jour. Geology, v. 69, no. 3, p. 241-260, 1961.

The calcareous shells of recent articulate brachiopods and fossils of the same class dating back to the Mississippian are investigated for their crystal form, O^{18}/O^{16} ratios, and $SrCO_3$ and $MgCO_3$ contents. Samples as old as Early Permian were found in which the relation of O^{18}/O^{16} ratios and the $SrCO_3$ and $MgCO_3$ contents are similar to recent species. The relation of the O^{18}/O^{16} to the $SrCO_3$ contents in a Late Mississippian sample is also similar to that in recent species. These findings make it probable that the O^{18}/O^{16} ratios and $SrCO_3$ and $MgCO_3$ contents in these fossils are the original ones. The significance of the chemical similarity of the fossil samples to recent shells is discussed. It is concluded that the results are best explained if it is assumed that the O^{18} , Sr and Mg contents, and the Sr/Ca and Mg/Ca ratios in the oceans have remained essentially constant during the last $2.0-2.5 \times 10^8$ yr. — V. S. N.

- 186-466. Clayton, Robert N., and Epstein, Samuel. The use of oxygen isotopes in high-temperature geological thermometry: Jour. Geology, v. 69, no. 4, p. 447-452, 1961.

Recent measurements on the oxygen isotopic fractionation between calcite and water and the oxygen isotope measurements on coexisting minerals permit the estimation of the isotopic fractionation factor as a function of temperature for systems involving any pair of the phases: quartz, calcite, hematite, and water. The use of these calibration curves for geological thermometry is illustrated for several natural samples. The isotopic composition of oxygen in hydrothermal fluids is also estimated from the measured O^{18}/O^{16} ratios in hydrothermal minerals. The mean value thus estimated is 6 percent greater than the oxygen of mean ocean water. — Authors' abstract

- 186-467. Khitrov, L. M., and Zadorozhnyy, V. I. Fractionation of isotope oxygen in the soil [English translation]: Pochvovedeniye, no. 1, p. 5-14, 1960; translation p. 3-10, 1961.

The results are reported from an investigation of the isotopic composition of oxygen in the air of four groups of soils taken from various depths at different times in order to determine the possibility of fractionation. Isotopic fractionation of the oxygen tends toward enrichment with O^{18} in some places; the enrichment is comparatively slight with the fractionation coefficient varying from 1.0004 to 1.0013. In view of this insignificant fractionation it is believed that the soil exerts little influence on the general enrichment of atmospheric oxygen during gas exchange between the atmosphere and the soil. — V. S. N.

- 186-468. Tilles, David. Natural variations in isotopic abundances of silicon: Jour. Geophys. Research, v. 66, no. 9, p. 3003-3013, 1961.

Measurements of natural variations in isotopic abundance ratios of silicon are reported. A maximum natural range of 5.3 per mil in Si^{30} has been observed to date. Coexisting biotite, quartz, and feldspars from some specimens of igneous rock from the Yosemite region differ by as much as 3 per mil; in other grossly similar igneous rocks from the same region the same minerals differ by less than 0.3 per mil. In those rocks with large differences between the minerals, the ratio of $[Si^{30}]/[Si^{28}+Si^{29}]$ increases in the order biotite, quartz, feldspar. All granitic rocks studied are enriched in Si^{30} with respect to meteorites and basic rocks. Measurements on some sediments and biologic samples covered a range of approximately 4 per mil. A group of tektites covered a range of less than 0.7 per mil, with isotopic abundances centrally distributed within the observed normal terrestrial range. The results are interpreted, and applications of such studies to problems of geothermometry and formation of igneous rocks are discussed. — Author's abstract

- 186-469. Tilles, David. Variations of silicon isotope ratios in a zoned pegmatite: Jour. Geophys. Research, v. 66, no. 9, p. 3015-3020, 1961.

Isotopic abundance variations of silicon in quartz and feldspar from the Rose Quartz pegmatite of the Pala district in southern California are reported. All feldspar samples are enriched in Si^{30} with respect to adjacent quartz samples, and the magnitude of enrichment varies from 0.6 to 2.7 per mil in Si^{30} . Feldspar-quartz differences were found to increase from outer zones towards the inner quartz core. All measurements on quartz samples were within a total range of about 0.6 per mil. The feldspar most heavily enriched in Si^{30} are believed to result from Rayleigh fractionation during crystallization from a vapor phase. — Author's abstract

- 186-470. Nakai, Nobuyuki, and Jensen, Mead LeRoy. Biogeochemistry of sulfur isotopes: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 181-196, 1960.

The fractionation of the sulfur isotopes S^{32} and S^{34} in the reduction of sulfate to sulfide in laboratory experiments and in nature has been studied. The factors of anaerobic viability, production rates of H_2S , and the extent of isotopic fractionation of sulfur reduced from SO_4^{-2} to H_2S have been determined with raw culture cells containing Long Island Sound mud and sea water that approximate natural conditions. Results indicate that there is a greater isotopic fractionation of sulfur by anaerobes in natural samples than in similar

natural samples to which additional nutrient was added. The fractionation of sulfur isotopes between SO_4^{-2} and S^{-1} of sea water and bottom mud is 1.021-1.031, and it is larger than that (1.005-1.007) of lake water and bottom mud. — V. S. N.

- 186-471. Cherdyn'tsev, V. V., Isabayev, Ye. A., Surkov, Yu. A., Orlov, D. P., and Usatov, E. P. Izbytok U^{235} v magnetite s povyshennyim soderzhaniyem aktiniya [Excess U^{235} in magnetite with high actinium content (with English abstract)]: *Geokhimiya*, no. 4, p. 373-374, 1960.

An excess of U^{235} has been detected in magnetites that also contain excess actinium. Both effects can be attributed to the complicated spontaneous decay of some transuranium isotope, small amounts of which still exist in nature. — D. B. V.

MAGNETIC FIELD OF THE EARTH

- 186-472. Roberts, P. H. Propagation of induced fields through the core [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 93-104, 1959.

A study is made of the hydromagnetic propagation of small magnetic disturbances from a source within a finitely conducting fluid to its boundary. The results are applied to the problem of the rate of growth of the magnetic field due to the centers of secular change. Several examples are given to illustrate that in a conducting fluid the diffusion of electromagnetic energy is generally much less rapid than its transmission by Alfvén waves; consequently, the conclusion by several authors, on the assumption that the core is a rigid conductor, that the disturbances responsible for the secular variation arise in a thin layer at the core boundary is incorrect. — V. S. N.

- 186-473. Bullard, E. C. Proiskhozheniye magnitnogo polya Zemli [Origin of the magnetic field of the earth]: *Priroda*, no. 12, p. 80-85, 1960.

Theories of origin of the magnetic field of the earth are discussed with an emphasis on the dynamo theory presented in previous papers (see *Geophys. Abs.* 151-14015 and 160-28). — A. J. S.

- 186-474. Herzenberg, A. Geomagnetic dynamos [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 85-89, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 522-525, 1958 (see *Geophys. Abs.* 176-245). — V. S. N.

- 186-475. Runcorn, S. K. On the theory of the geomagnetic secular variation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 105-109, 1959.

A basic assumption made in the interpretation of the directions of magnetization of rocks is that the mean direction of the field is that of a geocentric dipole oriented along the axis of the earth's rotation. The relative rotation of the core and mantle, inferred from the westward drift of the geomagnetic field and the irregular fluctuations of the length of the day, is shown to imply that even if a permanent non-dipole field could be generated in the core, the nonaxial parts would be averaged out by observations over a long time at the

earth's surface. The relative rotation also explains the clockwise rotation of the geomagnetic field vector observed at points on the earth's surface from observatory records covering a long period of time. — V. S. N.

- 186-476. McIntosh, D. H. On the annual variation of magnetic disturbance: Royal Soc. London Philos. Trans., v. 251, no. 1001, p. 525-552, 1959.

Statistical features of the annual incidence of magnetic disturbance over a wide range of intensity and latitude are exhaustively investigated by means of the K-index and related "planetary indices." Two distinct and physically significant components are identified, the annual component with summer maximum and winter minimum, and a semiannual component with equinoctial maximums. Both are found all over the world. The amplitude of the annual component increases markedly with latitude, whereas that of the semiannual component changes little with latitude.

The physical causes of the two types of variations are considered. It is concluded that the annual component is probably caused by an atmospheric dynamo effect and that the semiannual component is due to a systematic annual variation of the angle between the earth's magnetic axis and the sun-earth line, along which solar particles travel. — D. B. V.

- 186-477. Jardetsky, W. S. Polar wandering, shifting of the earth's axis and dipole variations [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 63-66, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 502-505, 1958 (see *Geophys. Abs.* 176-247). — V. S. N.

- 186-478. Herzenberg, A., and Lowes, F. J. The "Eddy Model" of the non-dipole field and the secular variation [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 89-92, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 526-534, 1958 (see *Geophys. Abs.* 176-246). — V. S. N.

- 186-479. Hutchinson, R., and Shuman, B. Rocket measurements of the magnetic field above New Mexico: Jour. Geophys. Research, v. 66, no. 9, p. 2687-2693, 1961.

Absolute value, total intensity measurements of the magnetic field above Holloman Missile Development Center, New Mexico, were obtained to an altitude of 236 km with a proton precession magnetometer aboard an Aerobee-Hi rocket. The flight took place on a magnetically quiet day during the normal midmorning variation. Comparison of the observed values with those predicted by spherical harmonic coefficients yields an anomaly of the order of 80 γ during ascent between the altitudes of 85 and 165 km, whereas no comparable effect was found for the descent portion of the flight down to 146 km. — Authors' abstract

- 186-480. Sonett, C. P., Judge, D. L., Sims, A. R., and Kelso, J. M. A radial rocket survey of the distant geomagnetic field: Jour. Geophys. Research, v. 65, no. 1, p. 55-68, 1960.

Data obtained by a magnetometer carried aboard the Pioneer I space probe over the intervals 3.7-7 and 12.3-14.8 geocentric radii indicate an inverse-

cube-field decrease in the region 3.7-13.6 radii, where termination takes place, with a subsequent decrease to 5×10^{-5} gauss. The surprisingly distant geomagnetic cutoff suggests a very low gas pressure on the day of the flight. Increasingly large (fractionally) fluctuations were observed with increasing radii. A gross variability in the vestigial field would suggest hydromagnetic activity of a complex gas cloud structure. — D. B. V.

- 186-481. Zmuda, Alfred J. Some characteristics of the upper-air magnetic field and ionospheric currents: *Jour. Geophys. Research*, v. 65, no. 1, p. 69-84, 1960.

Characteristics of the upper-air magnetic field and ionosphere currents are determined through an analysis of published rocket data on the magnetic scalar intensity. For the region between the earth's surface and the E layer of the ionosphere the observed values are compared with values obtained by extrapolating the surface vector field. Agreement is good for equatorial flights but only fair for a flight at White Sands, N. Mex. In the area above White Sands (geomagnetic lat 41° N.) a large negative anomaly exists, which may contribute to the formation of the region of low radiation intensity that lies between the two Van Allen radiation belts. — D. B. V.

Shaub, Yu. B. Interpretation of results of measurements of the angle of inclination of the polarization plane of a natural alternating magnetic field. See *Geophys. Abs.* 186-118.

Lipskaya, N. V., Deniskin, N. A., and Yegorov, Yu. M. The results of electromagnetic sounding in the central region of the Dnieper-Donets depression. See *Geophys. Abs.* 186-120.

- 186-482. Nicholson, Seth B., and Wulf, Oliver R[eynolds]. The diurnal variation of K indices of geomagnetic activity on disturbed days in 1940-1948: *Jour. Geophys. Research*, v. 66, no. 8, p. 2399-2404, 1961.

Local- and universal-time components of the diurnal variation of the K indexes have been computed from the 8 daily K numbers for the 5 disturbed days of each month in the 9 years 1940-48 from 6 observatories in moderately low latitudes. The local-time component shows no pronounced seasonal change. It has a maximum near 21 hr. The averages for each of the 9 years show a fairly regular change in amplitude over these years, particularly marked from 1943-47, that could be occasioned by an increase during this interval in a separate local-time component having a daytime maximum; its occurrence during these years suggests that it may be related to the solar cycle. The universal-time component shows a pronounced seasonal change. Although large differences from year to year are found, apparently at random in considerable measure, examination of the separate yearly averages shows a persistent tendency for disturbance to be somewhat less at certain universal-time hours than at others. — D. B. V.

- 186-483. Jacobs, J. A., and Sinno, K. Occurrence frequency of geomagnetic pulsations Pc: *Jour. Geophys. Research*, v. 65, no. 1, p. 107-113, 1960.

Analysis of the occurrence frequency of geomagnetic micropulsations Pc, using data obtained during the International Geophysical Year from a worldwide network of stations, shows that the occurrence frequency of Pc's increases as the auroral zones are approached, and depends not only on local

time but in part on universal time. The universal-time factor affects the modulation of the diurnal occurrence by about 50 percent. The time of maximum occurrence of Pc's is about 21^h G. m. t. in the northern hemisphere and opposite this in phase in the southern hemisphere. When the universal-time factor is maximum in the northern (or southern) hemisphere the north (or south) geomagnetic pole is about 16^h or 17^h L. m. t. The G. m. t. dependence derived in this investigation shows 7 hr difference compared with Troitakaya's conclusion based on data from U. S. S. R. stations (see Geophys. Abs. 154-14643, 159-31). — D. B. V.

- 186-484. Rao, K. S. Raja. Lunar daily variation of geomagnetic horizontal intensity at Alibag: Jour. Geophys. Research, v. 65, no. 1, p. 119-121, 1960.

Applying the Chapman-Miller method as described by Tschu, the lunar semi-diurnal variation of geomagnetic horizontal intensity (H) at Alibag, India, is worked out for the equinoctial season, using hourly values of H for the period 1940-44. The expression $L(H) = 1.2 \sin(2\tau + 62^\circ) \pm 0.3$ is obtained, where $L(H)$ is amplitude of lunar variation in H, and τ is lunar time reckoned from lower transit of mean moon at Alibag. $L(H)$ is maximum when the lunar time is 2 lunar hours past midnight or noon. The solar diurnal variation is also obtained up to 4 harmonics. Comparison with similar results for Kodaikanal, India, suggests that lunar and solar diurnal variations are independent of each other. — D. B. V.

- 186-485. Kakioka Magnetic Observatory. Geomagnetic observations made at Kakioka, Japan in 1958: [Japan] Kakioka Magnetic Observatory Rept., no. 29, 120 p., 1960.

The results of magnetic observations made at the observatory at Kakioka, Japan, during 1958 are reported in tables. The tables include hourly values of magnetic declination, magnetic horizontal intensity, and magnetic vertical intensity; mean hourly values of magnetic elements on all days, on calm days, and on disturbed days; mean hourly values of north and west components; three-hour range indices K and character figures C; and the general characteristics of principal magnetic disturbances. Magnetograms for 1958 are reproduced. — V. S. N.

- 186-486. Duncan, R. A. Some studies of geomagnetic micropulsations: Jour. Geophys. Research, v. 66, no. 7, p. 2087-2094, 1961.

Geomagnetic field oscillations with periods between 1 sec and a few minutes have been studied by means of large ground loops at Hobart, Adelaide, Camden, and Townsville, Australia. The period of the Pc's shows a diurnal variation and a marked dependence on latitude, shorter periods occurring at lower latitudes. Pt's are followed by magnetic bays with an average delay of about 15 min. "Sweepers," or oscillations with a progressive change of frequency and sometimes with aharmonic overtones, are observed during storms. — D. B. V.

- 186-487. Barsukov, O. M. Kvoprosu otrekh "skorostyakh" korpuskulyarnykh potokov [On the problem of three "velocities" of corpuscular streams]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 155-157, 1960.

By comparing the time and intensity of solar flares with geomagnetic activity, three maximums in geomagnetic disturbance were determined to occur

after passage of solar active areas across the central meridian of the sun. A graph of day-average relative intensities of telluric currents is presented to illustrate the 3 maximums. These maximums are considered to correspond to different "velocities" of the sun's corpuscular streams. — A. J. S.

- 186-488. Rikitake, Tsuneji. The anomalous behavior of geomagnetic variations of short period in Japan and its relation to the subterranean structure. The 9th report: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 4, p. 545-570, 1959.

The only possible model that can explain the anomaly in short-period geomagnetic variations observed in Japan seems to be a highly conducting, roughly elliptical circuit about 200 km wide and 1,000 km long, with both ends connected with the conducting part of the earth's mantle and with a nonconducting wedge penetrating into the mantle between these connecting points. This model also fits very well with the anomalies in Sq and Dst.

A study of the electromagnetic induction within a spherical sheet having a nonconducting hole demonstrates that the Japanese anomaly cannot be ascribed to the effect of electric currents induced in the sea. (See also Geophys. Abs. 158-50, 162-39 through 43, 163-27, 166-36, 174-264, 179-308.) — D. B. V.

- 186-489. Knapp, David G. Some features of magnetic storms in high latitudes: Jour. Geophys. Research, v. 66, no. 7, p. 2053-2085, 1961.

During a severe magnetic storm, observatory records obtained in high latitudes may show a type of disturbance here called a "cusped bay," which is characterized by a marked displacement of the trace coupled with augmented short-period fluctuations. Several of these events observed during the International Geophysical Year were measured on all appropriate magnetograms and plotted on maps as equivalent overhead current vectors. They show some of the characteristics of systems based on hourly-value changes during storms; however, they afford almost no evidence of the afternoon eastward segment of the auroral electrojet, and the polar-cap effects indicate patterns more complex than the one usually ascribed to this region. It is recommended that cusped bays be studied as a supplement to the use of hourly values and as a means of probing details of magnetic activity that are difficult to approach in other ways. A catalog of storms during the International Geophysical Year is given in an appendix by Knapp and Fabiano. — D. B. V.

- 186-490. Williams, V. L. The simultaneity of sudden commencements of magnetic storms: Jour. Geophys. Research, v. 65, no. 1, p. 85-92, 1960.

Rapid-run magnetograms from the U.S. Coast and Geodetic Survey (USC and GS) and from other observatories located near the magnetic equator were used to study sudden commencements that occurred during the period October 1957 to September 1958. Analysis of these magnetograms yielded three important results: (1) the sudden commencement always occurred first in high or middle latitudes; (2) Little America, Antarctica, registered the sudden commencement first or second 85 percent of the time; and (3) the apparent propagation velocities of the sudden commencement around the magnetic equator had average values between 1,145 and 2,835 km per sec. — Author's abstract

- 186-491. Piddington, J. H. Geomagnetic storm theory: Jour. Geophys. Research, v. 65, no. 1, p. 93-106, 1960.

A discussion of the two-gas theory of the transmission of geomagnetic disturbances through the atmosphere (to several earth radii) is extended (see also *Geophys. Abs.* 185-434) with the following results: (1) The central problem concerning the main phase of a geomagnetic storm is the mechanism of penetration of solar ions into the geomagnetic field. An explanation is given depending on a combination of a uniform electric space-charge field and a system of irregular fields. (2) A model of the main phase of a geomagnetic storm is given, the principal feature of which is a "magnetic tail" extending from the earth to the dark side. (3) The model may help to explain some other effects. (4) All observed geomagnetic disturbances have their sources initially in current systems in the lower ionosphere. Some are subsequently maintained by current systems in the earth itself and in the region of interaction between the solar and terrestrial plasmas; others are maintained by ionospheric currents. (5) Any ring current outside the geomagnetic field could cause an increase in the horizontal component; a westward-flowing ring current in the field could cause either an increase or a decrease in the horizontal component. The basic effect is not the current but a sustained inward or outward mechanical force on the material in which the current flows. — D. B. V.

186-492. Nagata, Takesi. On the earth storms I. General introduction: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 247-249, 1960.

There is much evidence to demonstrate that magnetic storms accompanied by ionospheric storms and auroral displays in the polar regions of the earth are caused by the solar corpuscular stream trapped and interacted upon by the earth's magnetic field. A significant number of problems concerning the mechanism of individual phenomena associated with the storms in the earth's upper atmosphere and outer space remain to be solved. Some of these problems are briefly reviewed as an introduction to the five other papers included in this volume (see *Geophys. Abs.* 186-493 through -497). — V. S. N.

186-493. Nishida, Atsuhiko. On the earth storms II. Stability of solar corpuscular stream: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 250-258, 1960.

The stability of a nonmagnetized stream propagating from the sun through interplanetary space is examined. Although electrons in the stream are lost due to collision with interplanetary plasma leaving only protons, the space charge thus introduced is sufficiently neutralized by the change in density of the interplanetary plasma that the stream can propagate stably both when there is no magnetic field and when there is a radial magnetic field in interplanetary space. It is concluded, therefore, that a nonmagnetized stream is capable of conveying the energy of a disturbance from the sun to the earth. — V. S. N.

186-494. Matuura, Nobuo, and Nagata, Takesi. On the earth storms III. Interaction between the solar corpuscular stream and the earth's magnetic field: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 259-272, 1960.

The effect of a stream of solar particles penetrating the exosphere is examined as a possible cause of magnetic disturbance. Solar particles of energy 20 Kev may penetrate the exosphere to a depth of nearly five times the earth's radius at about 10^5 sec after the arrival of the solar stream. The maximum density of the penetrated particles becomes nearly 10^3 cm^{-3} when the stream density is assumed to be 10^3 cm^{-3} . The total energy of the penetrating particles is estimated to be on the order of 10^{24} ergs; this may be sufficient to

explain the energy of the main phase of the storm. Furthermore, the penetrating solar particles may contribute to magnetic disturbances in high latitude regions and to variation in the radiation belts. Compression and heating of the exospheric gas as a result of compression of the earth's magnetic field by the solar stream may not be an important factor in world wide hydromagnetic instability in the exosphere. — V. S. N.

- 186-495. Nagata, Takesi, and Kokubun, Susumu. On the earth storms IV. Polar magnetic storms, with special reference to relation between geomagnetic disturbances in the northern and southern auroral zones: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 273-290, 1960.

Characteristics of south polar magnetic disturbances are compared with those of north polar magnetic disturbances. The SD-field pattern in the south polar region is almost a mirror image of that in the north polar region with respect to the geomagnetic equatorial plane, and K-indices are almost always parallel to K_p indices. Excellent correlation between activities at stations located on geomagnetically conjugate points indicates that the corpuscular stream originating in outer space tends to flow in along geomagnetic lines of force toward both the north and south ends of the earth's surface. In the case of large magnetic storms, however, the correlation between geomagnetically conjugate points becomes much poorer, suggesting that the relation between them is much disturbed owing to a heterogeneous magnetic field in outer space. — V. S. N.

- 186-496. Oguti, Takasi. On the earth storms V. Inter-relations among the upper atmosphere disturbance phenomena over the polar regions: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 291-300, 1960.

Observations made at Syowa station (lat 69°00' S., long 39°35' E.) were used to study the interrelationship of upper atmosphere disturbance phenomena in the auroral zone. Results suggest substantial reasons for believing that the polar geomagnetic disturbances are due to the motion of an electrical charge near the lower border of auroras caused by precipitation from a solar corpuscular stream, and that simultaneous ionization causes either an ionospheric blackout or an anomalous increase in fEs to follow the geomagnetic and auroral disturbances. The differences between blackout and increase in fEs is attributable to differences in the energy of the impinging particles. — V. S. N.

- 186-497. Tohmatsu, Takao, and Nagata, Takesi. On earth storms VI. Energy and flux of corpuscular streams impinging the earth's atmosphere: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 301-319, 1960.

The energy and flux of the corpuscular streams impinging on the earth's upper atmosphere during earth storms are estimated from their ionizing and exciting effects in three zones of the polar regions—the auroral, polar cap, and subauroral. In this study the energy and flux are estimated for an idealized earth storm, and the results obtained are summarized in a table giving the structure of the storm and its variation with respect to time and space. — V. S. N.

- 186-498. Ionosphere Research Committee, Science Council of Japan. Catalogue of disturbances in ionosphere, geomagnetic field, field in-

tensity of radio wave, cosmic ray solar phenomena and other related phenomena, No. 37: Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 321-383, 1960.

The results of simultaneous observations at 19 stations in Japan of the remarkable disturbances that occurred from March 29 to April 5, 1960, are presented in tables and graphs as follows: solar phenomena, solar radio emission, atmospheric radio noise, whistler occurrence number, principal magnetic storms, three-hour-range of earth-current potential, three-hour-range indices K and Ak, absolute zenith intensity of air-glow, ionosphere data, geomagnetic field and earth currents, induction magnetograms, cosmic-ray intensity, input intensity of radio waves, and field intensity of radio waves. — V. S. N.

- 186-499. Malurkar, S. L. Solar control of some unusually remarkable geophysical events [with Japanese abstract]: Papers in Meteorology and Geophysics, v. 11, no. 1, p. 144-150, 1960.

An examination of conditions on the sun shows that the emission of large cosmic ray bursts takes place only from limited portions—the western limb and the central meridian in a small latitudinal belt on either side of the equator—of an extremely active solar region with a long history. This area is relatively large and compact, and has a strong magnetic field. A large solar flare near the western limb of the sun gives rise only to a cosmic ray burst with no subsequent related geomagnetic storm; when the flare is near the central meridian, however, the cosmic ray burst is followed about a day later by a geomagnetic storm with corresponding world-wide cosmic ray changes. Purely geomagnetic storms follow about a day after the central meridian passage of active regions with lesser solar history. — V. S. N.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 186-500. Blundell, D. J. Rock magnetism applied to some geological problems: Geol. Mag., v. 98, no. 4, p. 301-312, 1961.

Recent studies with the application of rock magnetism to several geological problems serve to illustrate the scope of the methods at present available. Rock magnetism can usefully be applied to determine the age of a rock or to correlate it with some other. It may be used in studying the structural history of a formation or the thermal history of a rock. The examples cited deal with igneous rocks in Britain, but the methods also apply to some sediments and possibly to metamorphic rocks.

It is stressed that rock magnetism can be applied quite independently of any theory concerning the earth's field. It is necessary only to establish whether the magnetism measured in the laboratory is a true record of that acquired when the rock formed, or at some other known time in its history. — Author's abstract

- 186-501. Smelov, A. A. Kharakter namagnichennosti rud i priroda otritsatel'nykh magnitnykh anomalii Angaro-Ilimskogo rayona [Character of magnetization of ores and nature of negative magnetic anomalies of the Angara-Ilim area]: Leningrad Univ. Uchenyye Zapiski, v. 249, no. 10, Voprosy Geofiz., p. 194-230, 1958.

The results of field investigations of the origin of negative magnetic anomalies and of the magnetization features of ores found in Angara-Ilim area are reported. Several theories of the origin are discussed, and those proposed

by Bersudskiy (see *Geophys. Abs.* 94-4446) and Grabovskiy and Pushkov (see *Geophys. Abs.* 158-59) are found plausible. Smelov considers formation of negative anomalies in the Angara-Ilim area as being due to a low temperature dissociation in three-component magnetic rock, one component of which assumes the negative magnetization due to an internal demagnetizing moment that has a higher intensity than that of the earth's field. — A. J. S.

- 186-502. Strangway, D. W. Magnetic properties of diabase dikes: *Jour. Geophys. Research*, v. 66, no. 9, p. 3021-3032, 1961.

The magnetic properties of several Precambrian diabase dikes from the Canadian shield have been studied. The dikes are of widely differing ages and belong to swarms having greatly different strikes. Before demagnetization in a-c fields of 100-200 oersteds the direction of remanent magnetization of the various dikes were quite scattered, but after demagnetization a weak stable remanent magnetization was found. In almost all cases the direction of this stable magnetization was found to lie close to the plane of the dike, although the various dike swarms had different inclinations within the plane. Experiments showed that typical samples acquire a large soft thermoremanent magnetization at 585°C when cooled in the earth's field; a second weak but very stable component was also found that had a Curie temperature considerably lower than 585°C. It is postulated that the component with the high Curie temperature produced internal demagnetization that cancelled out the component of the earth's magnetic field normal to the dike; the component with the lower Curie temperature then acquired a magnetic moment parallel to the internal field of the dike, which would be nearly in the plane of the dike. This stable component may have been preserved since the time of formation. — D. B. V.

- 186-503. Grabovsky, M. A. (A) Magnetic properties of anisotropic rocks; and (b) The problem of the formation of remanence with an opposite polarity in rocks: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 67-69, 1959.

Anisotropy in rocks and its effect upon the magnetic properties of ferromagnetic stratified rocks are discussed in part A. From investigation of the structural anisotropy of a lamellar micaceous magnetic quartzite, it is shown that in a weak field the magnetic permeability of a sample in a direction parallel to the layers is tens of times more than that in a direction transverse to the layers. Moreover, given similar anisotropic samples, all magnetic values of thermomagnetized samples are greater than the values of isothermally (normally) magnetized samples. These studies are important in interpretation of magnetic and gravitational anomalies. Stratified rocks with layers parallel to the earth's surface will not be magnetized in the direction of the magnetic field and thus will not distort the earth's magnetic field, in which case regional gravity anomalies are not accompanied by magnetic anomalies. Under natural conditions the formation of remanence in stratified ferromagnetic rocks takes place as a result of thermomagnetization.

A series of model experiments to investigate ore deposits that show magnetic fields directed opposite to that of the earth's modern magnetic field are discussed in part B. [See also *Geophys. Abs.* 166-270, 176-267.] — V. S. N.

- 186-504. Chevallier, R[aymond], and Mathieu, S[uzanne]. Susceptibilité magnétique spécifique de pyroxènes monocliniques [Specific magnetic susceptibility of monoclinic pyroxenes]: *Soc. Chim. France Bull.*, pt. 5, Mem. no. 131, p. 726-729, 1958.

The results are reported of a theoretical determination of the magnetic susceptibility of monoclinic pyroxenes from the basaltic rocks of the Skaergaard intrusion and of a comparison with actual values determined by Brown and Vincent (1957) in the geology laboratory at Oxford University. Theoretically the lines of magnetic force are not rectilinear but, in intense fields, tend toward the right: where σ = the specific magnetization, σ_0 = a ferromagnetic impurity (10^{-3} to 10^{-4} percent magnetite, H = the magnetic field, and χ = the specific magnetic susceptibility of the pyroxene, then $\sigma = \sigma_0 + \chi H$. By solving this formula for each sample of the Skaergaard pyroxenes it is possible to determine the value of χ . Precise chemical analysis of these pyroxenes has shown that the magnetic ions are Fe^{2+} , Fe^{3+} , and Mn^{2+} . If it is assumed that these magnetic ions are free and without interaction, then using their known magnetic moments it is possible, by applying Langevin's law of paramagnetics (Curie's law), to calculate the susceptibility of the pyroxenes at 20°C . Comparison of the results with the measured susceptibilities shows very satisfactory agreement. — V. S. N.

- 186-505. Grabovskiy, M. A., Zherdenko, O. M., and Skovorodkin, Yu. P. O vozmozhnosti primeneniya metoda magnitnykh poroshkov pri issledovanii pirrotinovykh rud [On the feasibility of use of the method of magnetic powders in studies of pyrrhotite ores]; Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 737-743, 1961.

This is the continuation of a study of iron ores using magnetic powder (see Geophys. Abs. 184-484). Polished sections of pyrrhotite covered with cobalt ferrite powder of 1μ grain-size show magnetic nonuniformity not only for different grains of the rock but also within the area of individual grains. Lower temperature pyrrhotite takes a better coverage of powder than does the higher temperature. The crystallographic form and optical orientation can be determined by the character of settling of the powder with respect to the elongation of the grains. — A. J. S.

- 186-506. Nagata, T[akesi], Yukutake, T[akesi], and Uyeda, S[eiya]. On magnetic susceptibility of olivines: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 9, no. 1, p. 51-56, 1957.

Measurement of the magnetic susceptibility of several olivines, $x\text{Fe}_2\text{SiO}_4 \cdot (1-x)\text{Mg}_2\text{SiO}_4$ with varying x , has shown that the olivines are paramagnetic and that their molecular magnetic susceptibility can be expressed empirically by $X_{\text{mol}} = 2x \times 10^{-2} \text{emu/mol}$ at room temperature. Using the accepted value of the Bohr magneton number of Fe^{+2} ions and assuming that these ions are embedded in an isolated fashion in the crystal, the paramagnetic susceptibility of olivines at room temperature can be calculated as $X_{\text{mol}} = 2.2x - 2.6x \times 10^{-2} \text{emu/mol}$, provided that other constituents such as Mg^{+2} and SiO_4 are only diamagnetic. — V. S. N.

- 186-507. Uyeda, Seiya. Thermo-remanent magnetism and coercive force of the ilmenite-hematite series: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 9, no. 2, p. 61-78, 1957.

The thermoremanent magnetism and the coercive force of the ilmenite-hematite solid solution $(1-x)\text{Fe}_2\text{O}_3 \cdot x\text{FeTiO}_3$ are examined for the range $0 < x < 0.7$ in synthesized specimens; in the range $x > 0.7$, the solid solution is only paramagnetic at room temperature. In the parasitically ferromagnetic region ($x < 0.5$), $J(T)$ and $J_r(T)$ show an increase below the Curie point, while $H_c(T)$ and $H_{cr}(T)$ decrease monotonously with temperature. Thermoremanent mag-

netism is strong in comparison with $J(T)$ in this region, the Q -ratio amounting to several hundred. In the ferrimagnetic region ($0.7 > x > 0.5$), $J(T)$ and $J_r(T)$ show the typical straight decrease with temperature rise; H_c and the Q -ratio are considerably smaller than for the parasitically ferromagnetic region. Remarkable reverse TRM appears for specimens of the range bordering ferrimagnetic and parasitically ferromagnetic regions ($0.6 > x > 0.45$), which indicates that the phenomenon is inherent to this substance and closely related to fundamental magnetic properties of this series. A tendency for reverse TRM appears for $x \approx 0.1$; this may be similar to the natural reverse remanence of Adirondack rocks reported by Balsley and Buddington (see *Geophys. Abs.* 163-35). Stability against the AC demagnetization and the field dependence of the thermoremanent magnetism of this series also have been examined. — V. S. N.

- 186-508. Balsley, J[ames] R., and Buddington, A. F. Puzzles in the interpretation of paleomagnetism: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 553-580, 1960.

Paleomagnetic data are currently interpreted to indicate continental drift, polar wandering, and periodic reversal of the sense of polarity of the earth's magnetic field. Theory, experiment, and some geologic phenomena indicate that mineralogical factors should play a prominent role in evaluation of paleomagnetic data; yet, present interpretations largely ignore these factors and nevertheless arrive at a consistent picture. This puzzle is discussed, and major contributions in the field are reviewed and appraised. Until the role of minerals in the interpretation of paleomagnetism is satisfactorily understood and delineated, judgement on the validity of current interpretations must be suspended. — V. S. N.

- 186-509. Kalashnikov, A. G. Paleomagnetism i yego znachenie dlya poznaniya zemli [Paleomagnetism and its importance to knowledge of the earth]: *Akad. Nauk SSSR Vestnik*, no. 1, p. 27-38, 1961.

Paleomagnetism as applied to the history, dynamics, and structure of the earth is described. After an explanation of the fundamentals of paleomagnetic phenomena, methods of paleomagnetic investigations are reviewed. Generalizations from the observed variations of remanent magnetization vectors in space and time are summarized briefly and existing hypotheses of paleomagnetism given. The migration of the magnetic poles of the earth is discussed, and the correlation between paleomagnetism and paleoclimatology is considered to confirm the hypothesis of displacement of the earth's surface in relation to the earth's axis of rotation. In conclusion, the contribution of paleomagnetism to earth science is outlined. — A. J. S.

- Hodgson, R. L. Drift or shift. See *Geophys. Abs.* 186-378.

- 186-510. Bigarella, João José, and Salamuni, Riad. Early Mesozoic wind patterns as suggested by dune bedding in the Botucatú sandstone of Brazil and Uruguay: *Geol. Soc. America Bull.*, v. 72, no. 7, p. 1089-1106, 1961.

Early Mesozoic wind patterns and pressure belts, as determined from 2,892 measurements of eolian cross-bedding dip directions at 51 outcrops of the Botucatú sandstone in Brazil and Uruguay, are found to be in agreement with the paleomagnetic results reported by Creer and others (see *Geophys. Abs.* 176-273, 179-321). — D. B. V.

- 186-511. Rutten, M. G., and Veldkamp, J. Paleomagnetic research at the Utrecht University [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 60-62, 1959.

The results of paleomagnetic studies at the University of Utrecht on Miocene-Pleistocene basalts of the Coirons (southern France), Permian trachyandesites and basalts of the Oslo graben, and Permian rhyolites in the Esterel (southeastern France) are reported briefly. The pole deduced from the Esterel rhyolites (lat 45° N., long 130° E.) corresponds much more closely with the Permian poles found by Runcorn (Geophys. Abs. 163-46, 165-273) and Doell (Geophys. Abs. 164-234) in the United States than with the Permian pole found by Creer (Geophys. Abs. 173-292, -296) in England or by the Utrecht studies in the Oslo graben (lat 46° N., long 168° E.). In the Coirons the mean direction of the remanent magnetization coincides with the present field, thus supporting the conclusion of Hospers and others (Geophys. Abs. 157-40, 160-39) that the geomagnetic pole had already arrived in its present position in the Miocene. — V. S. N.

- 186-512. Bobier, Claude, and Glangeaud, Louis. Géodynamique et volcanisme du fossé de Montbrison et du horst du Forez (Morphotectonique, paléovolcanique et paléomagnétisme [Geodynamics and volcanism of the Montbrison graben and the Forez horst (Morphotectonics, paleovolcanology, and paleomagnetism)]: Soc. Géol. France Bull., ser. 7, v. 1, no. 8, p. 867-880, 1960.

This is virtually the same as the paper published in Acad. Sci. [Paris] Comptes Rendus, v. 250, no. 1, p. 162-164, 1960 (see Geophys. Abs. 181-387). — D. B. V.

- 186-513. Vlasov, A. Ya., Popova, A. V., Zvegintsev, A. G., and Rodicheva, E. K. Paleomagnitnyye issledovaniya osadochnykh tolshch devona tsentral'noy chasti Krasnoyarskogo kraya [Paleomagnetic study of sedimentary Devonian formations of the central part of the Krasnoyarsk district]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1022-1024, 1961.

The results of an investigation of natural remanent magnetization of Devonian sediments of the Krasnoyarsk area (central Siberia) are reported. A total of 380 samples from 13 outcrops were studied by measuring their vectors of remanent magnetization twice during an 8 months interval. The magnitude of the vectors was found to range from 0.1 to 40×10^{-6} CGSM, 12×10^{-6} CGSM being the average. The magnetic susceptibility is 15×10^{-6} CGSM. The accuracy of measuring remanent magnetization was established to be $\pm 0.2 \times 10^{-6}$ CGSM. The coordinates of the north magnetic pole for the Devonian period were found to be $\lambda_E = 155^\circ$ and $\phi_N = 28^\circ$. — A. J. S.

- 186-514. Nagata, Takesi, and Yama-ai, Mitsuko. Palaeomagnetic studies on rocks on the coast of Lützow-Holm Bay [with Japanese abstract]: Antarctic Rec., no. 11, p. 225-227, 1961.

As a continuation of earlier studies on Cambrian gneiss of the Ongul Islands (see Geophys. Abs. 180-291) results of paleomagnetic studies on a new collection of Cambrian specimens from the Ongul Islands and from the coast of Lützow-Holm Bay are reported. Magnetic orientation and the corresponding North pole positions obtained in the previous and present studies give nearly the same results. Uncorrected N-pole positions for the three collections are: East Ongul Island (1957-58) lat 19° N., long 163° W., East and West Ongul

Island (1959-60) lat 9° N., long 148° W., and east coast of Lützow-Holm Bay lat 21° N., long 156°W. A summary of these results and those of studies on Paleozoic, Mesozoic, and Cenozoic rocks in East Antarctica by others (see Geophys. Abs. 179-324, 184-497), when plotted together with the present geomagnetic pole, shows that the pole has shifted rather systematically from a position at the equator in Cambrian time toward the present position. — V. S. N.

MAGNETIC SURVEYS

- 186-515. Troshkov, G. A. K voprosu ob interpretatsii magnitnykh i gravitatsionnykh anomaly trekhmernykh tel [On the problem of interpretation of magnetic and gravity anomalies of three-dimensional bodies]: Razvedka i Okhrana Nedr., no. 12, p. 28-32, 1960.

A mathematical treatment is given for reducing three-dimensional anomalous gravimetric and magnetic fields to two-dimensional fields. The cases of a point pole, a spherical deposit, and a vertical prism of infinite depth are treated separately, and formulas are given for conversion of respective three-dimensional vertical components Z into two-dimensional components Z . The method proposed was tested on several objects and gave satisfactory results. — A. J. S.

- 186-516. Berkman, R. Ya., and Mikhaylovskiy, V. N. Izmeneniye napryazhenosti peremennykh magnitnykh poley nizkoy chastoty metodom dvoynogo preobrazovaniya signala [Variation of intensity of alternating magnetic fields of low frequency by the method of double transformation of the signal]: Prikladnaya Geofizika, no. 27, p. 212-222, 1960.

The problem of measurement of weak alternating magnetic fields in magnetic logging, in airborne electrical prospecting, and in other methods of geophysical exploration is discussed. The method of self-inductive coils presently in use is considered not sensitive enough, and a new method based on the principle of magnetic modulation by the investigated field of an auxiliary field of a stepped up frequency induced in a ferromagnetic element (the sounding device) is proposed. The application of magnetic modulation pickup for increasing the sensitivity of the field measurements is discussed. — A. J. S.

- 186-517. Wolf, H. Aeromagnetik im Dienste der Geophysik [Aeromagnetism in the service of geophysics]: Zeitschr. Angew. Geologie, v. 6, no. 6, p. 285-286, 1960.

This is a summary of a report on the literature dealing with aeromagnetic surveying, prepared in the VEB Geophysik at Leipzig in connection with plans for aeromagnetic investigations in East Germany. — D. B. V.

- 186-518. Haalck, Fritz, and Schulze, Reinhard. Die mit UTM erreichbare Genauigkeit [The accuracy attainable with the universal torsion magnetometer (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 5, p. 246-270, 1960.

The accuracy of measurements with the new Askania universal torsion magnetometer (UTM), the first of which went into service in 1958, is examined critically. Adjustments are described that make all second-order errors negligible. A measurement procedure that can eliminate first order errors is described, and the necessary formulas are given. If the suggested procedure is followed, with the temperature kept constant by means of the built-in

thermostat, the only constants that enter into the measurements are C_H and C_Z , which can be obtained by connecting measurements, and the induction coefficient k , which can be calculated with sufficient accuracy. Provided that the horizontal intensity H_0 is known accurately enough when the instrument is calibrated, a precision of $\pm 1\gamma$ may be achieved in measuring ΔH or ΔZ differences up to 10,000 γ between stations. — D. B. V.

- 186-519. Research Group for Proton Magnetometers (Japan). Proton magnetometers: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 125-143, 1960.

The design and construction of three magnetometers developed by the Research Group for Proton Magnetometers in Japan are described and their performance is discussed, where results are available. The sea-borne proton magnetometer, used mainly by the Japanese Antarctic Expedition, has a theoretical accuracy of ± 1 to 2γ and a practical accuracy (depending on the rotation of the detector coil in the wake and on the magnetization of the ship) of $\pm 15\gamma$. The direct-reading proton magnetometer with a signal counter was designed for use at the Syowa Station in the Antarctic; its accuracy should be $\pm 1\gamma$, but no observations are yet available. The portable transistorized proton magnetometer proved to be almost as accurate as the station-type proton magnetometer. It was used in the magnetic survey of Hakone Volcano (see Geophys. Abs. 186-530). — D. B. V.

- 186-520. Johnson, Robert W., Jr. Dimensions and attitude of the peridotite in Clark Hollow, Union County, Tennessee: An aeromagnetic study: Southeastern Geology, v. 2, no. 3, p. 137-154, 1961.

An aeromagnetic survey was made of an area in Union County, Tenn. underlain by an altered mica peridotite body. Resulting data indicate that the peridotite is a nearly vertical, elliptical cylinder approximately 1,500X3,000 feet in cross-section. It does not dip along the Wallen Valley fault and apparently was emplaced before the formation of the fault or before the last significant movement along the fault. — V. S. N.

- 186-521. Allan, Thomas Donald. A magnetic survey in the western English Channel: Geol. Soc. London Quart. Jour., v. 117, pt. 2, p. 157-168 (with discussion), 1961.

A magnetic contour map of the western English Channel is presented and interpreted. The map was compiled from profiles made during 6 expeditions of the R. R. S. Discovery II and the R. V. Sarsia; a nuclear spin magnetometer was towed behind the ships to measure the earth's total field. The most striking feature of the map is an anomaly 15 miles south of the Eddystone with a peak value of 360 γ and a total area of 360 sq mi. This is probably caused by basic rock brought up on a thrust-plane south of the Eddystone thrust. Sharp magnetic anomalies to the east of the Lizard show good correlation with basic intrusives on land. The boundary of the New Red Sandstone outcrops on the sea-floor, postulated from coring results, shows a remarkable coincidence with the extent of the sharp anomalies off the Lizard and off Start Peninsula. — V. S. N.

- 186-522. Park, R. Graham. A vertical force magnetic survey over part of the Dusk Water fault of North Ayrshire: Geol. Soc. Glasgow Trans., v. 24, pt. 2, p. 154-168, 1961.

A magnetic survey covering a square mile in the area of the Dusk Water fault in the Auchenmade district, near Dalry, North Ayrshire, Scotland is de-

scribed. The only important rocks of high magnetic susceptibility in the district are the basic lavas of the Calciferous Sandstone series; this series is cut by the Dusk Water fault which was found by the magnetic survey to swing smoothly from a northeasterly into an easterly direction. Both field mapping and magnetic results thus confirm that the northeast continuation of the Dusk Water fault (Waterside fault) is a splinter that branches from the main Auch-enmade fault. The thickness of the lavas was determined from magnetic profiles, depth and throw values were determined geologically, and susceptibility values of the lavas were determined experimentally. Several prominent anomalies are discussed. — V. S. N.

- 186-523. Angenheister, Gustav [H.], Dengler, Heinrich, and Hahn, Albrecht. Erdmagnetischen Messungen bei Waldhausen (Lahnmulde) als Hilfsmittel zur Aufsuchung devonischer Eisenerze [Geomagnetic measurements near Waldhausen (Lahn basin) as an aid in the search for Devonian iron ores]: Hesse Landesamt für Bodenforschung Notizbl., v. 87, p. 434-449, 1959.

A magnetic survey in the vicinity of the red ironstone occurrence of the Waldhausen mine indicates that the ore horizon, which in places is partially altered to magnetite by contact action with diabase, extends to the southwest. Two strongly magnetic layers younger than the ore bed—a diabase intrusion in the Lower Devonian and a diabase sheet in the Lower Culm—can be used as key beds in magnetic surveying. — D. B. V.

- 186-524. Bosum, W. Erdmagnetische Messungen im Deckdiabasgebiet der Dillmulde und ihre Auswertung [Geomagnetic measurements in the diabase sheet region of the Dill basin and their evaluation [with English abstract]: Zeitschr. Geophysik, v. 26, no. 3, p. 144-157, and no. 4, p. 177-216, 1960.

Geomagnetic measurements were made in the Dill basin in Hesse, Germany, in order to determine whether the different types of diabase could be distinguished by magnetic surveying. The results showed that continuous diabase sheets could be detected and their strike and dip could be determined from the vertical anomalies. Faults were also indicated. The magnetic interpretation was supported by geologic mapping, drilling, and measurements of the magnetic susceptibility and remanence of drill cores and hand specimens.

In the second part formulas for computing magnetic anomalies of two-dimensional bodies are established; this task was simplified considerably by the use of complex functions. A diagram (Komplexrechenplatte) is given for direct evaluation of the anomalies. Magnetic anomalies above the edges of disturbing bodies show less sharp maximums and minimums in real profiles than in theoretical ΔZ profiles, except above faults. Possible reasons for this discrepancy are discussed. — D. B. V.

- 186-525. Kalashnikov, A. G. Opyt primeneniya modelirovaniya dlya resheniya obratnoy zadachi magnitnoy razvedki [Experiment in the use of modeling for solution of the inverse problem of magnetic prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 345-348, 1961.

The Shchigry magnetic anomaly of the Kursk magnetic anomaly was investigated in the field and on a model of the ore body made of magnetite on a 1:22,000 scale, with a magnetic susceptibility $K=0.22$. By comparing the curve of the Z-component of the field data (maximum 1.25 oersted) with that of the model for $Q=0, 3, 5.7$, and 8.5 ($Q=I_r/I_{ind}$), a difference in the form of the

curves was found. Deviation of the field curve is due to nonuniform magnetization of the ore body because of its excessive magnetic susceptibility, considerable remanent magnetization of iron quartzites ($Q=8.5$), and nonuniform distribution of magnetized rocks in the upper parts of the ore body (Q up to 10-12). — A. J. S.

- 186-526. Pavlovskiy, V. I., and Rabinovich, V. B. Zadachi po poiskam bogatyykh zheleznykh rud KMA s uchetom novykh geofizicheskikh dannykh [Problems in prospecting for rich iron ores of the KMA on the basis of new geophysical data]: Razvedka i Okhrana Nedr, no. 12, p. 32-35, 1960.

A general discussion is presented of anomalous areas of the Kursk magnetic anomaly where large deposits of rich iron ores have been discovered by detailed geophysical explorations in the regions that were considered exhausted of new iron ore deposits. — A. J. S.

- 186-527. Mikhaylova, N. P. Magnitne pole ta deyakі rysy struktury Ntkopol'-Kryvorіz'koho rayonu [The magnetic field and some structural patterns of the Nikopol-Krivoy Rog region (with Russian summary)]: Akad. Nauk Ukrayin. RSR Heol. Zhur., v. 19, no. 6, p. 44-53, 1959.

A schematic structural map of the Nikopol-Krivoy Rog region in the Ukraine S. S. R. has been compiled on the basis of the physical properties of the rocks, the magnetic field, and a few gravity survey data. The region appears to be the nose of a broad northwest-plunging syncline that involves amphibolites and granites and is cut by faults. — D. B. V.

Kuznetsov, A. A., and Tavrin, I. F. Some data on the tectonic structure of the greenstone synclinorium on the east flank of the southern Urals according to results of gravity and magnetic surveys. See Geophys. Abs. 186-410.

- 186-528. Borisov, A. A., and Rymanov, V. M. O geologicheskoy interpretatsii magnitnykh anomalii yuga Sredney Asii [On the geologic interpretation of magnetic anomalies of southern central Asia]: Akad. Nauk SSSR Doklady, v. 133, no. 6, p. 1395-1397, 1960.

The magnetic anomalies in an area bounded on the north by the Zeravshan, on the east by the Darvaza and Pamir, and on the south by the Paropamisus Range are generally small, seldom exceeding +250 γ . Their distribution reflects the structure of the folded Paleozoic complex. Sketch maps show the distribution and intensity of positive and negative anomalies and their relation to structural elements. — D. B. V.

- 186-529. Bernshteyn, V. A. O vozmozhnykh izmeneniyakh magnitnogo polya v rayone vulkana Zavaritskogo v pervoye polugodiye 1958 g. [On possible changes in the magnetic field in the region of Zavaritskiy Volcano in the first half of 1958]: Akad. Nauk SSSR Lab. Vulkanologii Byull. Vulkanol. Sta., no. 30, p. 69-74, 1960.

Comparison of the results of a magnetic survey of Zavaritskiy Volcano in the Kurile Islands in August 1958 (see Geophys. Abs. 185-481) with those of a survey on December 19, 1957, just a month after the beginning of the eruption, shows a change of at least 450 γ . Such a difference, although possibly due to the methods used, could be a real one, related to displacement of the isothermal surface of the Curie point. The volcanic apparatus, a system of

fissures, might serve as a sensitive indicator of changes in volcanic activity by markedly influencing the magnetic field in the neighborhood of the volcano. Periodic magnetic measurements in the vicinity of volcanoes could give useful information on their activity, but for the data to be reliable it is necessary to use absolute measurements of the geomagnetic elements. — D. B. V.

- 186-530. Yukutake, Takesi, and Tanaoka, Iwao. Magnetic survey on Hakone Volcano by use of a proton magnetometer: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 41-54, 1960.

A magnetic survey of Hakone Volcano in Japan was undertaken in October 1959 in connection with the swarm of volcanic earthquakes that began the previous month. The new portable proton magnetometer developed by the Research Group for Proton Magnetometers (see Geophys. Abs. 186-519) was used.

The magnetic anomalies were found to reflect differences in magnetization of the different volcanic formations in the central part of the caldera—the Kamiyama, Komagatake, and Futagoyama lavas and the Kanto ash. The intensity of magnetization of the central cone, Mt. Kamiyama, is unexpectedly large for an andesitic volcano. A resurvey in the future should elucidate the relation between volcanic activity and geomagnetic changes. — D. B. V.

- McDougal, I., and Stott, P. M. Gravity and magnetic observations in the Red Hill area, Southern Tasmania. See Geophys. Abs. 186-411.

MICROSEISMS

- 186-531. Monakhov, F. I. Chastotnaya selektsiya okeanicheskikh shtormovykh mikroseyms [Frequency selection of ocean storm microseisms]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 393-401, 1961.

Microseisms experience much greater loss of energy during propagation on the ocean floor than on continental paths. Tracing cyclones passing over the open ocean is thus greatly limited. Microseisms from sources at great distances from the coast are found to be so weakened that their recognition on the records of ordinary seismic stations is not possible. Experiments were made to distinguish such microseisms at stations on continents and islands by the method of frequency selection using multicascade apparatus of 7.5 sec period natural oscillation. — A. J. S.

- 186-532. Monakhov, F. I. Mikroseymsy na dne Chernogo Morya [Microseisms on the bottom of the Black Sea]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 710-711, 1961.

Microseismic oscillations passing from the open ocean and sea to the land are discussed. A case is reported where microseisms on the bottom of the Black Sea 70 km west of Sochi were recorded as having a predominant period of 2 sec and maximum amplitudes up to 2μ . At the same moment the station of Sochi recorded microseisms of the same period with a 0.1μ amplitude. This phenomenon of a rapid drop in the amplitude of microseisms during the passage from sea to land is explained by considerable damping in the transition zone between the sea and the continent. — A. J. S.

- 186-533. Rykunov, L. N. Korrelyatsionnyy sposob izucheniya mikroseyms [Correlation method of study of microseisms]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1037-1039, 1961.

A correlation analysis of microseisms is presented whereby the Rayleigh, Love, and Lg wave microseismic components can be evaluated simply in any region where regular seismic stations are located. The results open a new possibility for study of transverse microseismic components whereby the information thus obtained is applied to the study of the nature and mechanism of production of microseisms and to the study of the upper part of the crust. — A. J. S.

- 186-534. Akamatu, Kei. On microseisms in frequency range of 1 c/s to 200 c/s: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 23-75, 1961.

The spectrum of short-period microseisms (frequency 1-200 c) has a characteristic "dominant frequency" at every observation point. At some places the spectrum may be remarkably sharp, at others it may be flat; the differences appear to be independent of the nature of the ground and of the time of day or night. Short-period microseisms appear to consist of surface waves, either Rayleigh or Love type or both. If so, the frequency corresponding to the minimum group velocity is apt to predominate. The ground layer acts as a kind of filter, and the dispersion curve inherent in the ground structure may be regarded as a characteristic frequency curve of the filter. — D. B. V.

- 186-535. Kishinouye, Fuyuhiko. Further studies of microseisms by observation: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 77-84, 1961.

Results of tripartite observations of microseisms at Shinkawa in Mitaka, at Tokyo, and at Tateno in Ibaraki Prefecture are presented graphically, together with weather maps for the observation days. — D. B. V.

- 186-536. Santo, Tetsuo A[kima]. Investigations into microseisms by the observational data of many stations (Part 2). — Further considerations on the origin of microseisms: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 483-494, 1959.

The suggestion made in the first part (see Geophys. Abs. 179-351) that microseisms of 3-7 sec period originate near the coast is reexamined in the light of additional data on microseismic storms due to passing typhoons, registered at many Japanese stations during the International Geophysical Year, together with oceanographic data on the distribution of swells around the running center of the typhoons. It was found that in all cases, regardless of the strength and distance of the cyclone center, microseisms in a given district occur simultaneously with the arrival of swells at some coast in the same district. This confirms the previous conclusion that the transformation of energy from swells to microseisms occurs somewhere near the coast. — D. B. V.

- 186-537. Santo, Tetsuo A[kima]. Where do swells turn into microseisms? [in Japanese with English abstract]: Zisin, ser. 2, v. 13, no. 3, p. 150-162, 1960.

During the International Geophysical Year period, observations of microseisms were made at many stations in Japan. Microseisms, resulting from the passing of a cyclone or typhoon near Japan, appear to occur at the time when swells from the meteorological disturbance reach some coast near the station. Comparison of microseismic amplitudes and swell heights at the same station supports this conclusion. Results of investigation of the period relation between microseisms and swells and of the spectrum of swells sup-

port Longuet-Higgins' standing wave theory (see *Geophys. Abs.* 144-12573). It is concluded that swells that are due to a single disturbance source in an ocean become microseisms at the point on a steep coast where standing waves are generated as a result of the interference of the incident and reflected swells. — V. S. N.

- 186-538. Hatherton, T. A note on the amplitude-period relationship of earth noise in the one to eight second range: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 13-16, 1961.

Maximum values of surface particle displacement due to microseisms recorded at an Antarctic seismological station (Scott Base) are compared with the displacements obtained by Romney [1953] at Harvard and Pinewoods. The relation of the displacement to the fourth power of the period obtained by Romney is confirmed by the Antarctic data. — Author's abstract

- 186-539. Byrne, C. J. Instrument noise in seismometers: *Seismol. Soc. America Bull.*, v. 51, no. 1, p. 69-84, 1961.

Methods are developed to analyze the effects of thermal noise and seismic noise in masking small earth vibrations. The procedure is applied to a simple seismometer, seismometers with electronic and galvanometer amplifiers, and a seismometer with a shunt capacity. A numerical example is worked out for the Benioff one-second instrument. In the 0.1 sec to 10 sec band, thermal noise is not limiting. — Author's abstract

- 186-540. Carron, Jean-Paul, Nozières, Philippe, and Rocard, Yves. Correlations entre séismographes voisins [Correlations between neighboring seismographs]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 16, p. 2430-2431, 1961.

Experiments were made in the Paris Basin in order to determine whether information on the residual agitation of the ground could be obtained by correlating seismic signals received by seismographs separated by a short distance. Two short-period (1 sec) instruments were used. When the seismographs were close together, the difference between signals (Δ) was zero. At 200 m apart, Δ was small and consisted only of high-frequency components. At a spacing of about 600-800 m the signals began to be out of phase, and at more than 800 m there was no correlation.

The range of correlation suggests a velocity of 1,000 m per sec, distinctly lower than the local P-wave velocity. This anomaly can be interpreted by assuming that the observed microseisms consist of surface waves resulting from nearby atmospheric disturbance or from settling of surface layers (over a thickness much less than the wavelength). — D. B. V.

- 186-541. Longuet-Higgins, M. S. Discussion of paper by J. N. Nanda, "The origin of microseisms": *Jour. Geophys. Research*, v. 66, no. 3, p. 994, 1961.

Nanda, J. N. Discussion on "The origin of microseisms": *Jour. Geophys. Research*, v. 66, no. 8, p. 2597-2598, 1961.

Longuet-Higgins calls attention to some misstatements in Nanda's paper (see *Geophys. Abs.* 181-403) that refer to Longuet-Higgins' paper on the origin of microseisms (see *Geophys. Abs.* 144-12573).

Nanda replies, giving reasons why he did not put too much reliance in Longuet-Higgins' theory applied to the incoherent sea. — D. B. V.

- 186-542. Shutt, T. C. Radioactivity and some of its geologic applications: Univ. Sheffield Geol. Soc. Jour., v. 3, no. 3, p. 77-81, 1959.

Radioactivity is defined and its natural occurrence and measurement discussed briefly. The direct effects and application of radioactivity to the following aspects of geology are summarized: the constant temperature of the earth, continental drift, dating the age of the earth, radioactive logging, and source of power. — V. S. N.

- 186-543. Savinskiy, I. D. O reshenii obratvoy zdachi pri γ -izmereniyakh [On solution of the inverse problem in γ -measurements]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 3, p. 379-386, 1961.

The problem of finding the density distribution of radioactive sources from their γ -radiation is discussed. A method of investigation of the possibilities for solving this inverse problem by employing the Fredholm integral equation of the first kind is proposed. The method is in principle applicable to cases of practically arbitrary distribution of radioactive material. — A. J. S.

- 186-544. Kenna, B. T., and Kuroda, P[aul] K. The ratio of induced fission vs. spontaneous fission in pitchblende and natural occurrence of radiochlorine: Jour. Inorg. Nucl. Chemistry, v. 16, no. 1/2, p. 1-7, 1960.

Chlorine was isolated from kilogram quantities of both Canadian and African pitchblende, exhaustively purified, and counted. The specific activity of chlorine obtained from African pitchblende was found to be (7 ± 1) disintegrations per minute per gram of chlorine, while that from Canadian pitchblende was (4 ± 1) disintegrations per minute per gram of chlorine. The ratio of induced fission of U^{235} vs. spontaneous fission of U^{238} in these minerals was calculated from the radiochlorine data. A value of 0.33 was obtained for the African pitchblende and a value of 0.19 for the Canadian pitchblende. — Authors' abstract

- 186-545. Goldsztein, M., and Guillermo, S. Radioactivité des laves de la Chaîne des Puys [Radioactivity of the lavas of the Chaîne des Puys]: Soc. Française Minéralogie et Cristallographie Bull., v. 84, no. 1, p. 6-8, 1961.

The distribution of radioactivity and of uranium in the lavas of the volcanic chain of the Puys in France has been measured; results are presented in graphs. The lavas form a perfectly continuous differentiation series. The correlation diagrams show that the uranium content varies systematically with the petrographic position of the rock in the series, confirming the tendency of uranium to be concentrated in the alkaline part of magmas. — D. B. V.

- 186-546. Hamilton, E. The uranium content of the differentiated Skaergaard intrusion: Grønlands Geol. Undersøgelse Misc. Papers, no. 22, 35 p., 1959; reprinted in Medd. om Grønland, v. 162, no. 7, 1959.

This paper was previously published in Univ. Copenhagen Mus. Minéralogie Géologie, Commun. Géol., no. 93, 35 p., 1959 (see Geophys. Abs. 181-410). — V. S. N.

- 186-547. Ueji, Torajiro. Some results obtained by the measurements of radioactivity in a certain bath-room of radioactive spring in Hyogo

Prefecture, Japan [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 9, no. 2/3, p. 52-57, 1958.

The results of radioactivity measurements with a scintillation counter of the water and air in a hot spring bathhouse are reported. It was found that the higher the temperature of the mineral water in the bathtub, the larger the radon emanation from the water. Readings of the counts in the air of the bathhouse proved to be irregular but were generally higher on the floor than in the upper parts of the room. — V. S. N.

- 186-548. Ueji, Torajiro. Radioactive mineral springs in Mt. Rokko and its environs near Kobe, Japan [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 11, no. 2/3, p. 29-33, 1960.

The results of an investigation of the radioactivity, temperature, and geologic relations for 65 mineral springs in the Mt. Rokko, Japan, area are reported. Radioactivity was found to be higher in springs of lower temperature. Zuihoji and Kurakuen springs have the highest radioactivity; both issue from biotite granite. — V. S. N.

- 186-549. Shimokata, K[ouzo], and Ishihara, H[iraku]. Radioactivity of mineral springs in middle Japan (VI). Radon and thoron content of mineral springs in Kiso district in the northern part of Aichi Prefecture [in Japanese with English abstract]: *Balneol. Soc. Japan Jour.*, v. 12, no. 1, p. 29-32, 1961.

The radon and thoron contents were determined for waters from 12 mineral springs in the Kiso district of Nagano Prefecture and in the northern part of Aichi Prefecture. The radon content of waters in the Kiso district was fairly high; the highest value was 106.2 Mache's units. Thoron was not detected. — V. S. N.

Rama; Koide, M.; and Goldberg, E. D. Lead-210 in natural waters. See *Geophys. Abs.* 186-458.

- 186-550. Sano, Shun-ichi. On the distribution of gamma ray intensity due to natural radioactivity near the earth's surface [with Japanese abstract]: *Japan Geol. Survey Rept.*, no. 188, 44 p., 1961.

The distribution of gamma-ray intensity due to terrestrial radioactivity was investigated by applying the inverse-square exponential law for a point isotropic source combined with a linear buildup factor to the calculation of distribution of gamma-ray intensity in the air and in a drill hole. The main purpose of the survey was to establish principles for outlining areas to be prospected for uranium ores. Measurements of the intensity in the air from a broad source or an effective half-space were made at various altitudes over a sand area on the coast of the Sea of Japan. The intensity distributions in a bare drill hole from a horizontal radioactive layer were calculated by substituting a line detector for an actual one. The effects expected theoretically are shown in figures that give examples of charts estimating the grade and thickness of an ore-bearing layer from a radioactivity log. The product of the grade and the thickness of the horizontal ore-bearing layer are obtained by integrating the intensity in the drill hole with respect to its depth, independently of the hole diameter or of the dynamic character of the ratemeter. — V. S. N.

- 186-551. Jurain, Georges. Sur la possibilité d'utiliser le dosage du radon des eaux souterraines dans la prospection des gîtes uranifères [On the possibility of using the determination of radon in ground waters in prospecting for uranium deposits]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 20, p. 3090-3092, 1961.

Recent work on radon activity of ground water (see Geophys. Abs. 177-323, 183-515) led to the conclusion that systematic determination of the radon content in such waters could be used to distinguish mineralized and nonmineralized zones in uranium prospecting. This conclusion has now been corroborated by tests in an area that has been surveyed geologically, radiometrically (on 25 m and 5 m grids), geophysically, by trenching and drilling, and geochemically. The method is rapid, accurate, and cheap, and can either replace airborne radiometric reconnaissance surveying or be used in a semisystematic phase of exploration. — D. B. V.

- 186-552. Singh, B. D. Radiometric prospecting: Jour. Mines, Metals, and Fuels, v. 9, no. 3, p. 16-20, 1961.

The instrumental principles of the Geiger and scintillation counters and their application to prospecting for nuclear raw material are discussed briefly. — V. S. N.

- 186-553. Matthews, W. L. Scintillometer survey in the Rossarden area: Tasmania Dept. Mines Tech. Repts., no. 4 for 1959, p. 12-17, 1960.

A ground survey for radioactive minerals was made in the Rossarden area, Tasmania, to check anomalies that had been indicated by an aerial scintillometer survey. Isorads drawn on a map show large areas to be from 1 1/2 to 2 times background count, a comparatively small area from 2 to 2 1/2 times background, and small isolated spots with readings greater than 3-4 times background. The higher readings are usually obtained from joint and fracture planes in granite. No new uranium deposits were discovered. The only method of finding possible deposits is to test fractures and joints for high counts. — V. S. N.

- 186-554. Dewan, J. T., Stone, O. L., and Morris, R. L. Chlorine logging in cased holes: Jour. Petroleum Technology, v. 13, no. 6, p. 531-537, 1961.

A chlorine logging tool developed primarily for detection of oil saturation behind casing is described. The principle of the method is based on the fact that chlorine has a large cross section for the capture of thermal neutrons, and in this capture process the chlorine nucleus emits characteristic gamma rays that can be measured. The usefulness of the method derives from the fact that most strata of interest for oil production contain saline formation water. When this water is replaced by oil, the chlorine content of the stratum is decreased significantly. The salinity resolution of the instrument is greatest at low salt concentrations and when the casing is empty. A method of interpreting the chlorine log based on response curves is explained and illustrated by several field examples from the Gulf Coast. — J. W. C.

- 186-555. Glauberman, A. E., and Tal'yanskiy, I. I. O raspredelenii neytronov v sredakh s zadannymi svoystvami pri tsilindricheskoy granitse razdela [Distribution of neutrons in mediums with given properties and with a cylindrical interface]: Atomnaya Energiya, v. 3, no. 7, p. 23-27, 1957.

An analytical treatment is presented of the distribution of neutrons from a point source in a medium containing a cylindrical interface where the regions inside and outside the cylinder have different neutron properties. The two-group approximation method, introducing fictitious sources at the interface of the regions, is employed. This permits a derivation of mathematical expressions for the fast and slow neutrons in both regions. — A. J. S.

Plewa, Stanisław. Problems of identification and correlation of coal seams by means of mining geophysics methods. See Geophys. Abs. 186-314.

Klyucharev, V. S., Shevkunov, Ye. N., and Lazarev, V. N. Study of carbonate rocks according to geophysical data. See Geophys. Abs. 186-316.

SEISMIC EXPLORATION

186-556. Tolstoy, I[van]. Elastic wave interferometry—a new tool: Jour. Geophys. Research, v. 66, no. 8, p. 2485-2488, 1961.

A harmonic source in a vertically stratified waveguide excites a number of propagating modes, each having its own characteristic wavelength in the horizontal direction. These modes interfere, giving characteristic oscillations of the wave field amplitude as a function of range from the source. In the case of a three-layered half-space the interference wavelength Λ of the first two modes is very sensitive to layer properties; in particular, if one examines the effect of the second layer, this wavelength is most sensitive in the range of parameters for which the usual seismic techniques are mostly inadequate. In principle, the method can be used in any properly chosen frequency range for both elastic and liquid mediums. Transient wave recordings (explosions, earthquakes, microseisms) obtained by a sufficient number of receivers could also be filtered to determine Λ and thus utilize this technique. Tables covering a wide variety of model types could be calculated with the aid of available computing machinery. — D. B. V.

186-557. O'Brien, P. N. S. A discussion on the nature and magnitude of elastic absorption in seismic prospecting: Geophys. Prosp., v. 9, no. 2, p. 261-275, 1961.

Field measurements of the amplitude attenuation of direct, reflected, and refracted pulses give values consistent with laboratory findings that seismic absorption in sedimentary rocks lies in the range 0.1-1.0 db per wavelength. It is shown that absorption must be nonlinear. It is assumed that for large values of "Q" the nonlinear equation of motion may be linearized and Fourier synthesis used. If this is valid, then attenuation per unit distance must be practically independent of frequency and dispersion must be negligible. Whatever mechanism is acting, it must produce an attenuation of about 1 db per 1,000 feet and a pulse broadening of about 1-2 percent in the same distance. More field and laboratory experiments to determine the physical mechanism of absorption would be extremely desirable. — D. B. V.

186-558. Weber, Max. Das ebene Interpretationsproblem der seismischen Lotung in einem zweiachsig inhomogenen Körper [The plane problem of interpretation of seismic sounding in a biaxial inhomogeneous body (with English summary)]: Geofisica Pura e Appl., v. 46, p. 33-36, 1960.

An exact solution is given for the general two-dimensional interpretation problem in seismic surveying, and illustrated by a simple example. — D. B. V.

- 186-559. Szendrei, M. E. The frequency content and attenuation of seismic wavelets along the surface of different types of soil: *Geofisica Pura e Appl.*, v. 46, p. 47-65, 1960.

An experimental investigation was conducted over six widely different types of soil in order to gain some reliable information on the wave properties relevant to seismic prospecting. The elastic constants of the surface layers were also found from the compressional and Rayleigh wave velocities. While the predominant frequencies of the compressional and Rayleigh waves both decrease with distance from the source, they are in most cases of the same order of magnitude. The amplitude of the particle velocity for the compressional wave was found to decrease inversely as the square of the distance, while that for the Rayleigh wave decreased more slowly; wide variations occur between different localities. The significance of these results to seismic prospecting instrumentation is discussed. — Author's abstract

- 186-560. Petrov, L. V. Osvyazi mezhdru chastotnymi kharakteristikami diskretnykh i nepreryvnykh grupp [On the relationship between frequency characteristics of discrete and continuous groups]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 3, p. 402-406, 1961.

A new expression for the frequency characteristic of a discrete group of seismic receivers in terms of the frequency characteristic of the reproducing continuous group, convenient for an array consisting of an even number of receivers, is given. It is shown that frequency characteristics of triangular groups of an even number of receivers for all frequencies do not have a modulus greater than the characteristics of groups of an odd number of receivers, provided the initial sensitivity characteristic and the interval between receivers are identical. — A. J. S.

- 186-561. Kitsunezaki, Choro. Study on high frequency seismic prospecting (I). On its application to exploration in metal mines [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 2, p. 102-107; and no. 3, p. 137-146, 1960.

The practical application of high frequency techniques of seismic prospecting to two metal mines in Japan is reported. The experimental instruments, essentially conventional instruments extended to high frequencies of 50-3,000 cycles per second, are described. Such problems as the effect on the seismic record of rock fissures and the sound, wind, and electrical disturbance resulting from the explosions are discussed. — V. S. N.

- 186-562. Suzuki, Takeo. On the velocity of elastic waves in a porous medium [in Japanese with English abstract]: *Butsuri-Tanko*, v. 13, no. 3, p. 147-159, 1960.

The unconsolidated materials near the earth's surface—the sedimentary layer, clastic rocks, and others—are treated as a porous medium, the elasticity of which is defined by the modulus of elasticity of the solid and liquid or gas constituents and of the framework. According to a formula by Gassmann (assuming that Poisson's ratio varies with the porosity) the velocity of the elastic wave in such a medium is considered as a function of the elastic constants of framework and porosity. The relations between the velocities of longitudinal and distortional waves and the bulk modulus of the framework are graphically represented for various values of porosity; from these, a chart that uses velocities of the longitudinal and distortional waves as parameters is constructed to show the relations. Young's modulus of a foundation rock for a dam site may be calculated by using seismic data and the charts. — V. S. N.

- 186-563. Kanda, Yutaro. Application of the values of velocity of elastic wave in the bed rock on the standpoint of engineering geology. Part II [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 3, p. 160-166, 1960.

The geologic information obtained during excavation of a tunnel is compared with the information previously obtained on the same area from a seismic survey. Techniques of interpretation of longitudinal wave velocities to obtain adequate geologic information for construction of civil engineering earthwork are discussed. — V. S. N.

- 186-564. Van Melle, F. A. Current research to improve the effectiveness of standard geophysical methods: Oil in Canada, v. 13, no. 29, p. 32-34, 1961.

The trend in current seismic research may be described as one of sophistication, of the application of modern analytical and statistical theories to the seismic field. This can be illustrated by tying various research developments to a diagram representing the factors which affect the seismogram by their equivalent electrical circuits. Although this trend seems to imply an increased premium on bigness of operations, there still is room for the small independent operator with an original approach and the ability to deliver quality data. — Author's abstract

- 186-565. Oilweek. Northern seismic costs cut in half by basic operation: Oilweek, v. 12, no. 11, p. 20-22, 1961.

A new method of conducting seismic exploration in the far north during the winter months is described. The heart of the method is the elimination of shot-hole drilling and the use of air shooting. Four-foot, hand-cut seismic trails are cut and recordings are made with light weight, portable transistorized magnetic instruments. The seismic crew is housed in snow-banked tents, and transportation consists of a small helicopter, a small supply plane, motorized toboggans, and snow shoes. This stripped-down operation cuts costs for operating in the far north in half and brings them to a level comparable with operations on the Alberta plains. — V. S. N.

- Bulin, N. K., and Savarenskiy, Ye. F. About short-period surface seismic waves. See Geophys. Abs. 186-199.

- 186-566. Gal'perin, Ye. I., and Frolova, A. V. Trekhkomponentnyye seismicheskiye nablyudeniya v skvazhinakh. I. Vertical'noye seismicheskoye profilirovaniye [Three-component seismic observations in boreholes. I. Vertical seismic profiling]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 793-809, 1961.

The methods of vertical seismic profiling and of seismic wave polarization are discussed, and their applicability to geophysical prospecting is considered. The application of correlation principles in tracing and separation of transmitted, reflected, and head (longitudinal and reflected transformed) waves is analyzed, using wave polarization data for a quantitative treatment of seismic observation data. The combined horizontal-vertical traveltime curves are given, and the nature of the reflected transformed wave of PS type is determined. — A. J. S.

- 186-567. Gal'perin, Ye. I., and Frolova, A. V. Trekhkomponentnyye seismicheskiye nablyudeniya v skvazhinakh II [Three-component seis-

mic observations in boreholes, II]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 979-993, 1961.

This is a continuation of the authors' previous paper (see Geophys. Abs. 186-566). The directions of displacement of ground particles by seismic waves are investigated in homogeneous and gradient mediums and in layered (thin and thick) mediums for the first and subsequent arrival waves. The three-component system consists of an assembly of three mutually perpendicular seismographs (2 horizontal and 1 vertical). The apparatus can be used for vertical seismic profiling with polarized waves, determination of a correlation between seismic horizons and stratigraphic contacts, determination of the nature of seismic waves and the boundaries producing the transformed (head and reflected) waves, determination of dynamic parameters of waves and characteristics of mediums, experimental determinations of various coefficients and parameters in studying methods and problems related to propagation of elastic waves, and study of velocity profiles in seismic logging. — A. J. S.

186-568. Offshore. Electronic filters eliminate seismic "singing": Offshore, v. 14, no. 6, p. 31, 1961.

A new and unique electronic filter designed to suppress the recording of interfering waves in reflection surveying over water is reported. The interference or singing is common in areas where the ocean floor is excessively hard or soft producing a rapid change in velocity of the wave as it moves from the water to the rock. This change causes much of the wave energy to bounce back and forth in the water reflecting alternately from the bottom and the surface. — V. S. N.

186-569. Dobrev, Toma B. Prilagane na reguliranoto nasocheno priyemane (RNP) na seizmichnite v"lny v Severoiztochna B"lgariya [Application of the method of controlled directional reception (RNP) of seismic waves in northeastern Bulgaria]: Minno-Geol. Inst. Godishnik, v. 6, pts. 1 and 2, p. 333-361, 1959-1960.

The seismogeologic characteristics of northeastern Bulgaria are discussed, and the quality of the seismic records available for the region are evaluated. The effectiveness of seismic exploration was found to depend largely on the depth of a rigid, high velocity (5.0-5.8 km/s) unit 700-900 m thick. It was found that the seismograms obtained by the method of reflected waves showed a "chaotic" pattern which prevented identification of informative waves. The method of controlled directional reception (RNP) applied to the field observations and laboratory experiments is described and found to produce data of a high resolving power. — A. J. S.

186-570. Khudzinskiy, L. L. Ob opredelenii nekotorykh parametrov sloev promezhutochnoy moshchnosti po spectrum otrazhennykh voln [On determination of certain parameters of layers of intermediate thickness from the spectrums of reflected waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 676-684, 1961.

A method is proposed for determination of the thickness of a layer when the elastic wave velocity in it is given, or for determination of the wave velocity in the layer when its thickness is given. Analytical and graphical determinations of both parameters, the magnitude of the errors involved, and the limits for the method are discussed. The method is based on the position of the zero and minimum components in the spectrum of the wave reflected from the layer. — A. J. S.

- 186-571. Kametani, Takuya; Tabata, Takeo; and Kawamura, Takashi. Checking deep reflection phases by vertical spread [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 3, p. 167-171, 1960.

The deep and steep phases on routine reflection records were examined to determine whether they represent true underground structures or the misreading of such coherent noises as superficial waves. By using a vertical spread of velocity type geophones, records were obtained showing that the phases were not from superficial waves. — V. S. N.

- 186-572. Kawashima, Takeshi, and Nagumo, Shozaburo. On the interpretation of seismic reflection method (1). Picking of reflections: Japan Geol. Survey Bull., v. 11, no. 10, p. 619-630, 1960.

A systematic procedure is presented for picking up reflections and as much other information as possible from a seismic record. Special attention is paid to the handling of poor records. — V. S. N.

- 186-573. Clément, A., and Layat, C. Correlation à distance constante en sismique réfraction [Correlation at a constant distance in seismic refraction surveying (with English abstract)]: Geophys. Prosp., v. 9, no. 2, p. 296-314, 1961.

Ordinary computation methods in refraction surveying in the Sahara involve considerable shot point distances, causing difficulties in operation and interpretation and high consumption of explosives. A method of reducing these distances is proposed, based on correlations of traces located in a critical zone, where waves have high relative energy due to the sudden increase of reflected energy beyond the critical angle and to the sudden appearance of refracted energy. In order to avoid certain difficulties, a constant correlation distance is selected, at least for sections of the profile.

The set-up and procedure of the proposed method are described in detail, and its advantages and limitations are discussed. — D. B. V.

- 186-574. Weber, Max. Zur Methode der fortgesetzten Auslage in der Refraktionsseismik [On the continuous profiling method in seismic refraction surveying (with English summary)]: Geofisica Pura e Appl., v. 47, p. 12-16, 1960.

A general mathematical treatment of the continuous profiling method is given and applied to the cases $c_1 = \text{const}$, to the plane n -layer problem, and to the case where c_1 is not dependent on z . — D. B. V.

- 186-575. Dobrev, Toma B., and Dachev, Khristo. Povtornite udary—precheshch faktor pri seizmoprouchvaneto po korelatsionniya metod na prechupenite v"lny (KMPV) [Secondary pressure bubble pulses as an interfering factor in seismic prospecting by the correlation method of refracted waves (KMPV)]: Minno-Geol. Inst. Godishnik, v. 6, pts. 1 and 2, p. 319-331, 1959-1960.

The results of observations of secondary pressure bubble pulses from underwater explosions carried out in the Black Sea are discussed. The empirical formulas and the statistical graph of the most probable zone where the records of the secondary pulses could appear do not confirm Yepinat'yeva's formula (see Geophys. Abs. 147-13222) derived to correlate the amount of explosive and the depth of the charge. Examples illustrating the interfering effect of the secondary pressure bubble pulses on the seismic records in un-

derwater exploration by the correlation method of refracted waves are discussed. — A. J. S.

- 186-576. Latypov, Zh. Uskorennyy sposob postroyeniya prelomyayushchikh granits metodom okruzhnostey [A rapid method of construction of refracting boundaries by the method of circles]: Akad. Nauk Kazakh. SSR Izv. Ser. Geol., no. 1 (42), p. 100-103, 1961.

Using a system of oppositely directed and mutually correlated point by point traveltimes curves of refracted waves, and applying principles of analytical geometry, a family of circles is constructed, the envelope of which represents the refracting boundary sought. The method is applicable to the boundaries of various forms having a moderate radius of curvature, provided the mean and boundary seismic velocity values are given. — A. J. S.

- 186-577. Seya, Kiyosi [Kiyoshi]. On an influence of anisotropy in a seismic refraction method [in Japanese with English abstract]: Butsuri-Tanko, v. 13, no. 2, p. 89-95, 1960.

It is assumed that in an anisotropic medium the wave surface of a P-wave is an ellipsoid. The general refraction law is reduced, and the influence of anisotropy is discussed for several basic geological formations. It is concluded that the true thickness of the layers is less than the thickness obtained by mathematical analysis. — V. S. N.

- 186-578. Voskresenskiy, Yu. N. O nekotorykh tipakh diffragirovannykh voln, obnaruzhyvayemykh metodom regulirovannogo napravlennoy priyema (RNP) [On certain types of diffracted waves observed by the method of controlled oriented reception (RNP)]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 2, p. 197-204, 1961.

Seismic data are analyzed for seismic waves of $P_{12}P_{21}$ and $P_{112}P_{21}$ type, generated by diffraction at the intersection of a fault and a shallow rigid interface. Among the recorded waves there were waves that were diffracted-refracted while traveling a certain part of their paths. — A. J. S.

- 186-579. Oblogina, T. I. Nekotoryye amplitudnyye osobennosti voln v sredakh s krutopadayushchimi granitsami razdela [Some amplitude features of waves in mediums with steeply dipping interfaces]: Moskov. Univ. Vestnik, no. 2, p. 52-60, 1961.

Wave diffraction must be taken into account in interpretation of seismic data in sections that contain steeply dipping interfaces. Examples of such structures are the sides of igneous intrusions and of salt domes. A graphic method is presented that treats diffraction at the points of acute, right, and obtuse angles. Where a contact dips steeply under an intrusion, diffraction is from an acute angle, and the amplitude of the curve of diffraction waves diminishes evenly along the profile with distance from the contact. Where a contact dips steeply under the country rock of an intrusion, diffraction is from an obtuse angle, and the amplitude of the diffracted waves first decreases but then increases and may become larger than that of the head waves being analyzed. — J. W. C.

- 186-580. Wyllie, M. R. J., Gardner, G. H. F., and Gregory, A. R. Some phenomena pertinent to velocity logging: Jour. Petroleum Technology, v. 13, no. 7, p. 629-636, 1961.

The major experimental facts that must be considered in interpreting continuous velocity logging data are reviewed. Velocity through liquid-saturated rocks depends primarily on porosity, and the time-average formula is reliable to within 5 percent for this parameter. An exception occurs in the case of shallow unconsolidated sands. Data are given for the dilatational and shear velocities through dry rocks under a high confining stress. A correction made for pressure increase or porosity reduction with depth in the interpretation of a velocity log is unwarranted because of the many uncertain parameters involved.

The theory of Biot concerning wave propagation in a porous elastic solid is used to show the probable influence of the viscosity, density, and velocity of the fluid saturants on the velocity through saturated rocks. This theory, although plausible, has not yet been subjected to rigorous experimental tests. It cannot be used to predict wave velocities in the absence of a fluid or in different porous media, and it does not lead to an evaluation of the effect of stress on velocity. Nevertheless, the theory is helpful in leading to a better understanding of the effects of various saturants and of signal frequency on measured velocity. — J. W. C.

- 186-581. Clarke, W. F. Sonic log applications—Eastern Venezuela [with Spanish abstract]: *Bol. Inf.*, v. 4, no. 4, p. 119-130, 1961.

The general theory of the measurement of acoustic velocities in porous mediums and the various factors affecting these velocities are discussed, and the application of the sonic log as a porosity and (or) hydrocarbon indicator in several areas in eastern Venezuela is described. Good conformity is found between the actual field data and the experimental and theoretical results although more field data are needed at shallower depths and at higher porosities to evaluate the tool further. A specific application of the sonic log would be in an area of low permeability, such as the Cascarancito area, Venezuela, where the economic potential is dependent on the sand permeability. Should comparison of sonic-derived porosities with core porosities from an intermediate depth show good correlation, then expensive coring at greater depths could be eliminated. — V. S. N.

Müller, Gerhard. Velocity determinations of elastic waves in frozen rocks and the application of acoustic measurements to investigations of the frozen belt at frozen shafts. See *Geophys. Abs.* 186-269.

- 186-582. Hobson, George D., and Collett, L. S. Some observations with a hammer refraction seismograph: *Canadian Inst. Mining and Metallurgy Trans.*, v. 63, p. 449-456, 1960.

The methods used and results from reconnaissance surveys in Ottawa, to the south of Montreal, and in southwestern Ontario by the Geological Survey of Canada using a Model MD-1 refraction seismograph are described. Measurements of depths of overburden were successful to a maximum depth of 190 feet; accuracy was found to decrease from about ± 10 percent to depths of 75 feet to about ± 15 percent below 100 feet. At the greater depths or on days of high noise level, primacord and seismic caps were used. It is concluded that this apparatus is useful and economical for certain applications. Perhaps the most important use to the geologist would be in groundwater studies and to the engineer in the search for gravel and clay deposits, dam sites, sewer work, and tunnel and pipeline construction. — V. S. N.

- 186-583. Ewing, J[ohn] I., and Tirey, G. B. Seismic profiler: Jour. Geophys. Research, v. 66, no. 9, p. 2917-2927, 1961.

A seismic profiler designed to reduce the time required for analysis of marine seismic refraction and reflection data and to display the data in profile form to facilitate correlation of arrivals, is described. The detector is a piezoelectric crystal hydrophone, the amplifiers are transistorized, modeled after those normally used in seismic refraction work, and the recorder is a modified Times Facsimile drum recorder. Profiling is achieved by initiating the drum rotation with the shot-instant signal. Refraction data are displayed in the form of a standard time-distance plot, the distance scale being determined by the speed of the shooting ship and the time scale by the speed of rotation of the drum, which can be preset. Reflection data are recorded in section form, analogous to standard echo sounder records. A choice of full-wave or half-wave rectification is available, and logarithmic or linear amplifier response can be selected as desired. — D. B. V.

- 186-584. Hersey, J. B., Edgerton, H. E., Rayomond, S. O., and Hayward, G. Pingers and thumpers advance deep-sea exploration: ISA Jour., v. 8, no. 1, p. 72-77, 1961.

Two new sonic transducers—a pinger and a thumper—which provide much increased accuracy to underwater exploration are described. The sonar pinger makes it possible to lower equipment into deep water to a desired position above the bottom. The instrument sends out short bursts of sound periodically that travel directly up to the ship as well as reflect off the bottom. Both pings are sensed by a sonar receiver on the ship and the time difference between their arrival measures the pinger-to-bottom distance. The pinger may be used to position under water cameras, water-sampling bottles, coring tools for deep ocean floor samples, and geothermal probes for measuring temperature of ocean floor sediments. It is also usable for making detailed topographic surveys of the ocean floor.

The sonar thumper is designed to generate sound waves for seismic exploration of the crust under the ocean floor. The instrument puts a large amount of acoustical energy into the water in the form of a clean, low-frequency, repeatable pulse. The actual transducer consists of a flat aluminum plate held against the face of a flat coil by means of a spring. When current flows through the coil the plate is driven away from the coil to produce a "thump" in the water. Sub-bottom penetrations of several hundred feet have been obtained using the present 1,000 w-sec input thumper. The thumper can be designed as a part of a ship or can be a submersible unit equipped with batteries which can be lowered to great depth. — V. S. N.

- 186-585. Ivakin, B. N., and Vasil'yev, Yu. F. Yemkostnyye priyemniki ul'trazvukovykh impul'sov [Capacity receivers of ultrasonic impulses]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 725-729, 1961.

A capacity receiver is proposed that is based on the change of capacity of a plane-parallel condenser when the distance between its plates is changed by an ultrasonic wave passing through the plates and an acoustically soft dielectric layer (air). Under these conditions absolute ultrasonic displacements can be determined in a model or in the field. The circuit and construction diagrams of the device are given. Models tests show that capacity receivers can be used advantageously in ultrasonic seismic investigations. — A. J. S.

- 186-586. Hoskins, Hartley, and Knott, S. T. Geophysical investigation of Cape Cod Bay, Massachusetts, using the continuous seismic profiler: *Jour. Geology*, v. 69, no. 3, p. 330-340, 1961.

The Woods Hole Oceanographic Institution's continuous seismic profiler was used in Cape Cod Bay to make 200 miles of reflection profiles and to establish 8 oblique reflection-refraction stations. From these the areal extent and velocities of the principal seismic layers were determined. The deepest layer, 4.6-5.0 kmps, is interpreted as Paleozoic in age; its top surface forms an open-end basin which deepens northeastward from the northeast entrance of Cape Cod Canal. Erosional remnants of Cretaceous sediments, 3.0-4.0 kmps, overlie the Paleozoics. Three horizons in the 1.8-2.4 kmps range are of still younger age; the deepest is probably marine Tertiary; the intermediate is glacial till, and the shallowest is a thin covering of postglacial sediments. The paper is well illustrated with maps and cross sections. — V. S. N.

- 186-587. Milne, W. G., and White, W. R. H. A seismic survey in the vicinity of Vancouver Island, British Columbia: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 7, p. 145-154, 1960.

Information on crustal structure in the area adjacent to Vancouver Island, British Columbia, has been obtained from the seismic records of a series of depth charges detonated in the vicinity of the island. In general the area has a granitic basement (seismic velocity of 6.29 kmps) that crops out on Vancouver Island and on the mainland; this layer may or may not extend to the base of the crust. South of Victoria the granitic layer is covered by a volcanic rock (velocity of 5.4 kmps); measurements of depth and of the dip of the bottom interface of this bed were obtained. A considerable thickness of low-velocity material was found under the Strait of Georgia, and near the site of the Ripple Rock explosion a low-velocity volcanic rock rests on the basement. Surface velocities were measured in all of these areas using portable refraction equipment. — V. S. N.

- 186-588. Reich, H[ermann]. Zur Frage der geologischen Deutung seismischer Grenzflächen in den Alpen [On the problem of the geologic interpretation of seismic discontinuities in the Alps (with English summary, p. 697)]: *Geol. Rundschau*, v. 50, p. 465-473, 1960.

Reflection and refraction observations of large quarry and borehole blasts in the Helvetic zone and in the Flysch at the edge of the Alps in Upper Bavaria indicate the presence of two discontinuities, at 5 km and 11 km below sea level, respectively. The former represents the basement surface; the latter the Försch discontinuity. Several other discontinuities were noted above the basement; these indicate the presence of Mesozoic formations. Some steeply dipping boundaries must be thrust planes. — D. B. V.

- 186-589. Godin, Yu. N., Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seismicheskiye issledovaniya zemnoy kory v Bukharskom rayone Uzbekskoy SSR [Seismic investigations of the earth's crust in the Bukhara area of the Uzbek SSR]: *Akad. Nauk SSSR Doklady*, v. 134, no. 5, p. 1069-1072, 1960.

Crustal structure in the Bukhara-Khivin region of the Uzbek S.S.R. was investigated seismically in 1959. A low-frequency modification of the correlation refraction method and the deep reflection method were used simultaneously to determine the relief and depth of the Paleozoic basement and for detecting waves from the lower boundaries of the crust. Waves from horizons

in the sedimentary layer and from the surface of the Paleozoic basement were detected using shot-point spacings of 12-17 km and waves from the base of the crust using shot-point spacings of 40-70 km. Results are given in a profile from the Amu Dar'ya River on the west to the Nuratau Paleozoic massif on the east. The average thickness of the crust is 45 km, ranging from 40 km in the east to 48 km in the Amu Dar'ya area. The granitic and basaltic layers are fairly constant and can be estimated approximately as 15-17 km and 18-20 km thick, respectively.

Comparison with the Fergana intermontane basin suggests that the thickness of the crust diminishes abruptly toward the northern Tien Shan and evidently would not exceed 40 km in the very center of the range. — D. B. V.

- 186-590. Kosminskaya, I. P., and Krakshina, R. M. O zakriticheskikh otrazheniyakh ot granits Mohorovichicha [The transcritical reflections from the Mohorovičić discontinuity]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 822-834, 1961.

Fundamental data on the kinematics and dynamics of the transcritical waves (reflected waves recorded at distances from the shot point greater than distances to the initial point of the traveltime curves of the waves refracted at the same boundary) reflected from the M-discontinuity are given. Seismograms obtained in the northwest and central parts of the Sea of Okhotsk and in the Pacific Ocean east of the Kurile-Kamchatka trench are analyzed. The effective seismic velocities in the crust are determined, and the M-discontinuity is constructed from the traveltime curves of the transcritical waves. An attempt was made to determine if a specific layer occurs over the M-discontinuity. Some indications were obtained that the transcritical and P-waves refracted at the M-discontinuity travel through a medium composed of more than a single layer.—A. J. S.

- 186-591. Tanaka, Akiyoshi, and Ninagawa, Shinji. Geophysical prospecting in the eastern part of Kushiro City, Hokkaidō [in Japanese with English abstract]: Japan Geol. Survey Bull., v. 11, no. 8, p. 503-518, 1960.

Results of seismic refraction and gravity surveys carried out in the eastern part of Kushiro City, Hokkaidō, Japan, in 1957 and 1959 are presented. The surveys were for the purpose of determining the subsurface structure as a guide in the exploitation of the coal field in the area. Five seismic velocity layers were identified; the fifth or the basement rock (Cretaceous) forms a shallow basin, which is approximately 860 m below the surface at its deepest part. The gravity map indicates that the basement deepens toward the northwest from the Harutori district. Residual gravity anomalies suggest the presence of minor subsurface structures. — V. S. N.

International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha. See Geophys. Abs. 186-602.

STRENGTH AND PLASTICITY

- 186-592. Brace, W. F. Mohr construction in the analysis of large geologic strain: Geol. Soc. America Bull., v. 72, no. 7, p. 1059-1080, 1961.

A semigraphical method of analysis of large strain based on Nadai's strain component and utilizing a Mohr construction is outlined for problems of in-

terest in structural geology. Finite homogeneous strain theory is applicable to measurement and analysis of strains from geologic features small enough to be included within regions of homogeneous strain. Use of this theory and of the strain ellipsoid and its properties implies nothing about isotropy or homogeneity of the rocks or about the stress-strain relation during deformation and therefore its application is valid over a much wider range of phenomena than usually realized. Examples of strain analysis are worked out in detail to illustrate both the versatility and the limitations of the method. — D. B. V.

- 186-593. Matsushima, Shogo. On the flow and fracture of igneous rocks: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 36, p. 1-9, 1960.

The stress-strain relations of some igneous rocks were observed in both longitudinal and lateral direction at atmospheric pressure and room temperature using a strain gauge of the electric resistance type. Curves of longitudinal strain versus stress were approximately linear up to the moment of rupture, but the strain in the lateral direction showed an abrupt increase in the fracture range. This abrupt increase of lateral strain was found to be closely related to the flow. Longitudinal creep during moderate pressure recovered almost entirely upon removal of load, but in the lateral direction a large amount of residual strain was observed after the removal of load. The empirical formulas for creep in granite are $S = A_0 + A_1 e^{-\alpha_1 t} + A_2 e^{-\alpha_2 t} + A_3 e^{-\alpha_3 t} + B \log t + Ct$ for the longitudinal direction, and $S = A + B \log t + Ct$ for the lateral direction, in which α_1 , α_2 , and α_3 denote the retardation times. — V. S. N.

- 186-594. Matsushima, Shogo. On the deformation and fracture of granite under high confining pressure: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 36, p. 11-20, 1960.

The stress-strain relations for granite were observed experimentally under various high confining pressures. It was found that the mean Young's modulus is numerically constant independent of increasing pressure. However, low pseudo-Poisson's ratio, characteristic of the first stage of loading, is gradually lost with increase of the confining pressure, and the volume increase in the fracture range decays. The empirical formula for the pressure-strength relationship is given by: $P = P_0 * (k P_H + 1)^{\frac{1}{2}}$. Since the above phenomena are closely connected with compressibility (porosity), the pressure-strength relation was calculated using Griffith's pore theory. This calculated relationship, deduced from the empirical equation of compressibility with pressure, gives the same formula as the above empirical one. — V. S. N.

- 185-595. Adadurov, G. A., Balashov, D. B., and Dremin, A. N. Issledovaniye ob'emnoy szhimayemosti mramora pri vysokikh davleniyakh [Research on volume compressibility of marble under high pressure]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 712-716, 1961.

The compressibility of marble under confining pressure up to 500,000 kg per cm^2 was investigated. The compressibility up to 30,000 kg per cm^2 and temperatures of 20°C to 95°C was investigated by the method of piston displacement in a piezometer (isothermic data), and in the interval between 50,000 and 500,000 kg per cm^2 by the method of shock compression. Polymorphic transitions accompanied by a jump in density were observed at pressures of 11,000, 16,000, 22,000, and 150,000 kg per cm^2 . The compression values obtained by the isothermic and the shock methods do not lie on the same curve. This implies that polymorphic changes due to isothermal compression are not accomplished by the shock compression. — A. J. S.

- 186-596. Langleben, M. P. Some physical properties of sea ice, pt. 2: Canadian Jour. Physics, v. 37, no. 12, p. 1438-1454, 1959.

Some properties of annual sea ice at mid-temperature latitudes were investigated. Salinity is comparable to and density much lower than that in annual arctic sea ice. Tensile strength depends on crystal size rather than on brine content. (See also Geophys. Abs. 177-184.)—D. B. V.

- 186-597. Mathews, W. H., and MacKay, J. R. Deformation of soils by glacier ice and the influence of pore pressures and permafrost: Royal Soc. Canada Trans., ser. 3, v. 54, sec. 4, p. 27-36, 1960.

Deformation of unconsolidated material by glacier ice has been observed in the Western Canadian Arctic and has been reported in other glaciated regions. It is believed to result from thrusting near the terminus of an actively moving lobe of ice, and available evidence suggests that mixed and cohesionless soils, if not the clays, were frozen when deformed, thus indicating the presence of permafrost. High pore pressures which might develop below the permafrost may facilitate thrusting by reducing the shear strength of the soils. The conditions sufficient for a moderate thickness of permafrost to develop under an advancing ice lobe and for pore pressures to build up are discussed.—V. S. N.

- 186-598. Austin, Carl F. Impulse loading of rock targets to produce fracture patterns similar to naturally occurring radial dyke systems: Nature, v. 190, no. 4772, p. 227-229, 1961.

Experiments to investigate the striking similarity between fractures induced by impulsive loads in some rock types and the great dikes swarms occasionally encountered in volcanic provinces are described. Heavy cast-iron lined-cavity shaped charges were fired into light-colored limestone targets. Three basic patterns were observed in the plane perpendicular to the axis of penetration: penetration with essentially no fracturing; radial fractures around a circular or elliptical penetration; and fractures at right angles to the walls of a penetration having a rectangular or angular cross section.—D. B. V.

- 186-599. Hobbs, D. W. The strength and stress-strain characteristics of Oakdale coal under triaxial compression: Geol. Mag., v. 97, no. 5, p. 422-435, 1960.

Laboratory measurements on the Oakdale metallurgical coking coal show that the effect of an applied confining pressure produces considerable changes in the strength and stress-strain characteristics of the coal. Several fold increases in axial fracture stress, axial yield stress, Young's modulus, and elastic strain at the yield point were observed as the confining pressure was increased from 0 to 5,000 psi. The results are discussed in relation to various criteria of failure. It was found that failure was represented by Coulomb's equation relating shear stress and normal stress, provided the observed angles of fracture were not influenced by local edge stress concentrations.—V. S. N.

- 186-600. Scheidegger, A[drian] E[ugen]. On the connection between tectonic stresses and well fracturing data: Geofisica Pura e Appl., v. 46, p. 66-76, 1960.

In hydraulic fracturing treatment of wells, the pressure required to cause formation breakdown depends in part on prevailing geologic stresses. A new

model is proposed in which the stress state produced by the fluid pressure in the well is no longer fundamentally two-dimensional. It is assumed that the pressure in the well is equivalent to a spherical pressure center. The fracture condition is formulated, and the model is applied to the calculation of underground stresses from well data. — D. B. V.

- 186-601. Yuan, T'ieh-chang. Slow shearing on a strain shearing instrument [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 4, p. 21-26, 1960.

The laboratory method used to determine the shear strength of soft soil is described. The stress-control, strain-control shearing instruments are described and illustrated. Because the shear strength of the same soil as determined by the stress instrument is always larger than that determined by using the strain instrument, studies were conducted to determine the elements that affect the shear strength of the soil. It was found that the time elapsed during the course of shearing has an important effect on the strength of the soil. — V. S. N.

SUBMARINE GEOLOGY

- 186-602. International Geophysical Year Bulletin No. 46. Arctic Basin seismic studies from IGY Drifting Station Alpha: Am. Geophys. Union Trans., v. 42, no. 2, p. 239-243, 1961.

Reflection and refraction seismic measurements made between July 1957 and November 1958 from Drifting Station Alpha in the Arctic Ocean pack ice reveal the Alpha Rise, one of the large positive features of Arctic Ocean topography. Relief on the rise is rugged, apparently due to block faulting.

Refraction results show that the average thickness of the unconsolidated layer is 0.38 km, compared to $\frac{1}{2}$ -1 km in the North Atlantic; a deeper, 4.7-kmps layer is 2.8 km thick; and this is underlain by an "oceanic" layer having a velocity of 6.44 kmps, in close agreement with the 6.5 kmps velocity found in the North Atlantic. — D. B. V.

- 186-603. Miyake, Yasuo, and Sugimura, Yukio. Ionium-thorium chronology of deep-sea sediments of the western North Pacific Ocean: Science, v. 133, no. 3467, p. 1823-1824, 1961.

The rate of deposition of deep-sea deposits collected at depths of 6,215-8,450 m in the northwest Pacific Ocean was estimated from the ionium/thorium ($\text{Th}^{230}/\text{Th}^{232}$) ratio, determined by means of an alpha-ray spectrometer, to be 0.5-0.8 mm per 10^3 yr for the upper 10 cm of the sea floor. — D. B. V.

- 186-604. Dulberger, Leon H. Sonar to survey Arctic Ocean shelf transmits through ice and water: Electronics, v. 34, no. 31, p. 44-45, 1961.

Sonar designed to survey the Arctic Ocean continental shelf through surface ice or directly in water is now in use. The sonar's transducer is coupled to the ice by a layer of high-viscosity oil to achieve maximum sound transfer. The instrument is described and a schematic diagram is presented. — V. S. N.

- 186-605. Seibold, Eugen. Der Boden der Ozeane und die Erdgeschichte [The floor of the oceans and earth history]: Naturwissenschaften, v. 48, no. 9, p. 319-323, 1961.

This is a review of deep sea geologic research. After a discussion of the horizontal and vertical distribution of deep sea sediments and their dating, the late history of the Pacific Ocean as deduced from the sedimentary record is outlined to illustrate the results obtained with new methods and the problems remaining to be solved. — D. B. V.

186-606. Leonov, A. K. *Regional'naya okeanografiya, chast' 1* [Regional oceanography, pt. 1]: Leningrad, Gidrometeoizdat, 765 p., 1960.

This is a predominantly hydrological treatise based on theoretical and observational data. The geologic history and morphology of the basins of the Bering, Okhotsk, Japanese, Caspian, Black, and Azov Seas are discussed separately. The geology of the sea floor, the bottom sediments, and the tectonics of the basin margins are treated for each. — A. J. S.

Hersey, J. B., Edgerton, H. E., Raymond, S. O., and Hayward, G. Pingers and thumpers advance deep-sea exploration. See *Geophys. Abs.* 186-584.

VOLCANOLOGY

186-607. Rittmann, Alfred. *Fortschritte der Vulkanologie* [Progress in volcanology]: *Experientia*, v. 16, no. 6, p. 232-237, 1960.

The chief results of recent volcanological research along different lines are reviewed. The most important of these concern the origin of magma (primary and anatectic), the mechanism of eruptions, the geographic distribution of volcanoes and "magma series," and the intimate relations between volcanic and tectonic phenomena. The general conclusions are drawn that volcanism should be regarded as a process of degasification of the earth, and that use of physical and chemical methods contributes to the ultimate progress of the essentially geologic science of volcanology. — D. B. V.

186-608. Shimazu, Yasuo. A thermodynamical aspect of volcanic gas: *Nagoya Univ. Jour. Earth Sci.*, v. 8, no. 2, p. 197-221, 1960.

The role of water vapor at the final stage of magmatic differentiation and the intimate relation between volcanic eruption and development of volcanic gas phases are discussed. The solubility of water in residual melts is not so large that melts become saturated with water by cooling and crystallization, but a solubility gradient is set up and a local supersaturated state realized when temperature and (or) pressure gradients exist within a magma reservoir. Assuming an albite-H₂O binary magma and applying the thermodynamics of irreversible processes the following results are found: (1) In an undersaturated magma when an upward decreasing temperature gradient and the height of the magma reservoir are fixed as constants, crystallization and melting take place at the top and bottom of the reservoir respectively. (2) In a super saturated magma, when hydrodynamic flow exists within the reservoir both water vapor and albite melts develop at the top and albite crystallizes at the bottom. Under these conditions the pressure at the top is 1.25 kb greater than that of the surrounding rocks and an explosion of the reservoir may occur when the height becomes >1 km. When floating-up of gas bubbles is possible a large pressure rise occurs at the top and explosions of the magma take places easily. The numerical values of gradients of temperature, pressure, concentration, transfer rates of magma and gas, and reaction rates are given in a table. Varia-

tions in composition of volcanic gas emitted at the surface from a magma reservoir and the relationship to the physical conditions of the magma reservoir are discussed also. — V. S. N.

- 186-609. Matsuo, Sadao. On the origin of volcanic gases: Nagoya Univ. Jour. Earth Sci., v. 8, no. 2, p. 222-245, 1960.

A theoretical study of the chemical composition of magmatic gases in three different kinds of magma (basaltic, dacitic, and granitic) is reported. It is believed that many of the gaseous components are produced in a magma by the oxidation-reduction reactions between water vapor and the component minerals. A very close correlation is found between chemical composition of the magmatic gases and the mineral assemblage of the magma; the more basic the magma the higher is the hydrogen content and the lower is the content of sulfur compounds in the magmatic gases under conditions of constant temperature-pressure. The content of sulfur dioxide in the gases is highly sensitive to variations in pressure and temperature, whereas, the content of other components is rather insensitive to such variations. This may afford a chemical means of forecasting volcanic eruptions. The chemical compositions of lavas observed at Kilauea in Hawaii and at Showashinzan in Hokkaido, Japan, are discussed. The analyzed composition of the Kilauea lava-lake gases and the calculated composition (at 1 atm pressure and 1,500°K) of the gases in the basaltic magma agree with each other within the range of scattering of analytical results and thermodynamic uncertainties. At Showashinzan Volcano estimates based on the composition of the volcanic gases suggest a depth of a few kilometers for the magma reservoir with a magma at 1,300°K under pressures of $2\sim3\times10^2$ atm. — V. S. N.

- 186-610. Castello Branco, A. de, Zybszewski, G., Moitinho de Almeda, F., and Veiga Ferreira, O. da. Rapport de la première mission géologique [Report of the first geologic mission], in *Le volcanisme de l'île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 9-27, 1959.

This report begins with an outline of the geology of the western part of Fayal Island in the Azores; then presents observations on the activity of Capelinhos Volcano up to the first appearance of lava. During the period September 27-November 3, 1957, the volcano was born and the first two islands were formed and destroyed. In the period November 4-December 16, 1957, a third island appeared and joined the mainland as it grew. The first lavas appeared on December 17. Activity in the period covered in this report was typical of submarine volcanoes. (See also Geophys. Abs. 173-361, 175-409, -410, 178-429.) — D. B. V.

- 186-611. Zbyszewski, G., and Veiga Ferreira, O. da. Rapport de la deuxième mission géologique sur le volcanisme de l'île de Faial [Report of the second geologic mission on the volcanism of Fayal Island], in *Le volcanisme de l'île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 29-55, 1959.

The volcanism of eastern and central Fayal Island in the Azores, the geologic structure of the island, and natural resources related to volcanism (mineral waters and building materials) are discussed; then observations of the

activity of Capelinhos from December 17, 1958 to November 30, 1959 are presented. Activity during that time can be divided into three distinct periods: Lava began to flow on December 17, 1958, but explosive activity and ejection of pyroclastic material predominated until May 12, 1959; after the strong earthquake of May 13 and until October 25, activity was predominately effusive and typically strombolian, particularly in August; after October 25 all activity ceased except fumarolic. — D. B. V.

- 186-612. Tazieff, H[aroun]. L'éruption de 1957-58 et le tectonique de Faial (Açores) [The eruption of 1957-58 and the structure of Fayal (Azores)], in *Le volcanisme de l'île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 71-88, 1959.

This paper is almost identical with that published in the Soc. Belge Géologie, Paléontologie, et Hydrologie Bull., v. 67, no. 1, p. 13-36, 1959 (see Geophys. Abs. 178-429). — D. B. V.

- 186-613. Machado, Frederico. A erupção do Faial em 1672 [The Fayal eruption in 1672], in *Le volcanisme de l'île de Faial et l'éruption du volcan de Capelinhos* [The volcanism of Fayal Island and the eruption of Capelinhos Volcano]: Portugal Serviços Geol. Mem., no. 4, p. 89-99, 1959.

The 1672 eruption on the island of Fayal in the Azores is reconstructed on the basis of contemporary reports and field study of the lava flows. The eruption was preceded by a swarm of earthquakes with focuses located near the active vents at a depth of about 3 km. Activity began on April 24 with short-lived explosive activity followed by extrusion of lavas, which flowed for 10 months and covered the western part of the island. The volume of lava is estimated at about $360 \times 10^6 \text{ m}^3$ (of which only $16 \times 10^6 \text{ m}^3$ remained above sea level), averaging a little more than $1 \times 10^6 \text{ m}^3$ per day. Total energy liberated during the whole activity is calculated as about 10^{25} ergs. — D. B. V.

Yukutake, Takesi, and Tanaoka, Iwao. Magnetic survey on Hakone Volcano by use of a proton magnetometer. See Geophys. Abs. 186-530.

- 186-614. Kizawa, Takashi. A study of earthquakes in relation to volcanic activity (3)—Earthquakes during the period of activity of Volcano Usu (1934-1945), two new phases of the earthquakes, and earthquakes of crypto-volcanic activity at Ito [with Japanese abstract]: *Papers in Meteorology and Geophysics*, v. 11, no. 1, p. 30-96, 1960.

The principal results of a study of earthquakes associated with the activity of Usu Volcano, Hokkaido, Japan, from 1943 to 1945 are reported. The distribution of epicenters of A-type (prior to eruption) earthquakes was determined from the value of the distance coefficient ($k=8.2$ km/s) obtained by analysis of 7 A-type earthquakes associated with formation of the new cone, Showa Shinzan; the depth of the hypocenter was determined to be about 10 km. Study of the decay in frequency and amplitude with time shows that eruptions occurred after the earthquakes had declined. The value of the absorption coefficient for two major A-type earthquakes in January 1944 was determined from the maximum ground amplitude and epicentral distance as $5.8 \times 10^{-3} \text{ km}^{-1}$ when $25 < \Delta < 700 \text{ km}$, and as $5.6 \times 10^{-3} \text{ km}^{-1}$ when $25 < \Delta < 800 \text{ km}$. These values

are almost identical with the values determined by Wadati (1931) for tectonic earthquakes within the same magnitude range (6.2 to 5.4); thus it is concluded that the A-type volcanic earthquakes of Usu are similar to tectonic earthquakes. A crustal model in the vicinity of Usu giving the depth to the M-discontinuity as $H=25.0$ km was derived from the reflected S-waves.

From a study of both A- and B-type earthquakes on the seismograms at Mori Observatory two new phases of waves with paths largely in shallow sea water were observed. These are treated as Rayleigh waves. Detailed results have been published previously (see *Geophys. Abs.* 182-134, 183-159).

The mean values of m in the Ishimoto-Iida formula, $n d A = K A^{-m} d A$, which expresses the relationship between frequency n and amplitude A of an earthquake, are calculated from data of the Itô crypto-volcanic activity and the Kita-Izu earthquake swarms in 1930 as $m=1.85$ and 1.50 , respectively. The value of 1.85 for the Itô activity is nearly equivalent to values obtained from A-type earthquakes of volcanic origin, whereas the lower value of m for the Kita-Izu earthquake swarms suggests a different mechanism. The values of m for the earthquakes at Tesikaga, Tango, Nankai, and Fukui have been calculated as 1.91 , 1.7 , 1.8 , and 1.9 , respectively. — V. S. N.

- 186-615. Shima, Michiyasu. Volcanic micro-tremors at the Volcano Aso: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 34, 17 p., 1960.

The results of an investigation of microtremors at Aso Volcano, Japan, since 1950 are reported. Microtremors of Love (type 1) and Rayleigh (type 2) types, according to Sassa's classification of four types (1935), are discussed here. These microtremors stop suddenly before an eruption and increase again following an eruption; this phenomenon was observed during the period of the eruptions of April 1953, December 1957, and June 1958. At the time of an eruption the value of the NS-EW components of amplitude of type-2 microtremors increases from 0 to 1, and it is assumed that the fracture paralleling the row of craters vibrates along with the magmatic reservoir after an eruption. The azimuthal distribution of amplitude is calculated, and the results indicate that the transverse component is of the same order of magnitude as the longitudinal component. — V. S. N.

- 186-616. Yuhara, Kozo. On the Uchinomaki hot springs in Aso Caldera: Balneol. Soc. Japan Jour., v. 11, no. 4, p. 61-71, 1960.

Ninety hot springs have been bored at Uchinomaki in Aso Caldera. They range from 50 to 190 m in depth, from 32°C to 49°C in temperature, and have a combined flow rate of 3,084 l per min. Since investigations in 1940 and 1952, the mean depth and total flow rate of the springs have increased noticeably while the maximum temperature has remained the same. The content of Cl , SO_2 , HCO_3 , Na , and Ca of the water varies roughly with temperatures. In the center of the hot spring area the waters are high in N_2 and low in O_2 suggesting that the source is from vadose waters, moreover the present activity of Aso Volcano does not affect the hot springs. The heat source is unquestionably volcanic, however. — V. S. N.

- 186-617. Koga, Akito. Chemical studies on the hot spring of Beppu (13). The local specific feature of the Beppu hot spring (1) [in Japanese with English abstract]: Balneol. Soc. Japan Jour., v. 9, no. 2/3, p. 63-68, 1958.

The deviation of the SO_4/Cl ratio from that of sea water was determined for the waters of 80 hot springs in the Beppu area, Kyushu, Japan. In general,

this deviation was found to be larger in the hilly districts than near the sea coast. — V. S. N.

186-618. Sahara, Ryotaro. The chemical studies of the hot spring waters in Akita Prefecture: Akita Univ. Mining Coll., Research Inst. Underground Resources Rept., no. 22, p. 32-69, 1960.

The results of chemical analyses of waters from 122 hot springs in Akita Prefecture, Japan, are reported. It was found that the waters of hot springs along the Ōu mountains in the Nasu volcanic zone have compositions characteristic of hot springs of volcanic origin. These springs along the coast of the Japan Sea and Lake Hachiro have saline waters related to the brine waters found in the nearby oil and natural gas zones. — V. S. N.

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By JAMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, *and others*

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*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



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By James W. Clarke, Dorothy B. Vitaliano, Virginia S. Neuschel, and others

INTRODUCTION

Extent of Coverage

Geophysical Abstracts includes abstracts of technical papers and books on the physics of the solid earth, the application of physical methods and techniques to geologic problems, and geophysical exploration. The table of contents, which is alphabetically arranged, shows the material covered.

Abstracts are prepared only of material that is believed to be generally available. Ordinarily abstracts are not published of material with limited circulations (such as dissertations, open-file reports, or memorandums) or of other papers presented orally at meetings. Abstracts of papers in Japanese and Chinese are based on abstracts or summaries in a western language accompanying the paper.

List of Journals

Lists of journals published in Geophysical Abstracts 160 (January-March 1955, Bulletin 1033-A) and subsequent issues through 184 (January-March 1961, Bulletin 1146-A) have been compiled into a single list, which may be obtained by writing to the U. S. Geological Survey, Washington 25, D. C.

Supplements to this master list have been published in each issue since Geophysical Abstracts 184. The following is an additional supplement that lists references cited in Geophysical Abstracts 187 that have not been listed previously.

Am. Assoc. Adv. Sci. Pub. -- American Association for the Advancement of Science Publication. Washington, D. C.

Australasian Inst. Mining and Metallurgy Proc. -- The Australasian Institute of Mining and Metallurgy Proceedings. Melbourne, Australia.

Azerbaydzhan. Nauchno-Issled. Inst. po Dobyche Nefti Trudy -- Azerbaydzhanskiy Nauchno-Issledovatel'skiy Institut po Dobyche Nefti Trudy -- [The Azerbaijan Research Institute for Oil Production Transactions]. Baku, U. S. S. R.

Géodésie et Géophysique Comptes Rendus -- Comptes Rendus du Comité National Français de Géodésie et Géophysique. Au Secrétariat General du Comité Français [Proceedings of the French National Committee of Geology and Geophysics. At the Secrétariat General of the French Committee]. Paris, France.

Geofísica Internac. -- Geofísica Internacional. Revista de la Unión Geofísica Mexicana, auspiciada por el Instituto de Geofísica de la Universidad Nacional Autónoma de México [International Geophysics. Journal of the Geophysical Union of Mexico, Sponsored by the Institute of Geophysics of the National University of the State of Mexico]. Mexico, D. F., Mexico.

Geol. Soc. London Proc. -- Geological Society of London Proceedings. London, England.

Geologie u. Bauwesen -- Geologie und Bauwesen [Geology and Construction]. Springer Verlag, Wien (Vienna), Austria.

Inst. Physique du Globe Paris Annales -- Annales de l'Institut de Physique du Globe de l'Université de Paris et du Bureau Central de Magnétisme Ter-

- restre [Annals of the Institute of Physics of the Globe of the University of Paris and of the Central Bureau of Terrestrial Magnetism]. Paris, France.
- Internat. Jour. Appl. Radiation and Isotopes -- International Journal of Applied Radiation and Isotopes. Pergamon Press Ltd. London, England.
- Israel Ministry of Devel., Geol. Survey Bull. -- State of Israel, Ministry of Development, Geological Survey Bulletin. Jerusalem, Israel.
- Kentucky Geol. Survey Spec. Pub. -- Kentucky Geological Survey Special Publication. University of Kentucky. Lexington, Kentucky.
- Kyoto Univ. Eng. Research Inst. Tech. Rept. -- Technical Reports of the Engineering Research Institute, Kyoto University. Kyoto, Japan.
- Kyushu Inst. Technology Bull. -- Bulletin of the Kyushu Institute of Technology. Fukuoka, Japan.
- Maine Geol. Survey Rept. -- Maine Geological Survey Report, Department of Economic Development. Augusta, Maine.
- New Zealand Geographer -- New Zealand Geographer. New Zealand Geographical Society. Auckland, New Zealand.
- Norske Inst. Kosmisk Fysikk Pub. -- Publikasjoner fra Det Norske Institutt for Kosmisk Fysikk [Publication from the Norwegian Institute for Cosmic Physics]. Magnetisk Byrd, Bergen, Norway.
- Northern Ireland Geol. Survey Mem. -- Memoirs of the Geological Survey, Ministry of Commerce, Government of Northern Ireland. Belfast, Ireland.
- Nyasaland Geol. Survey Rec. -- Records of the Geological Survey of Nyasaland. Zomba, Nyasaland.
- Oceanus -- Oceanus. The Woods Hole Oceanographic Institution. Woods Hole, Massachusetts.
- Oklahoma Geology Notes -- Oklahoma Geology Notes. Oklahoma Geological Survey. Norman, Oklahoma.
- Pakistan Jour. Sci. and Indus. Research -- Pakistan Journal of Scientific and Industrial Research. Pakistan Council of Scientific and Industrial Research. Karachi, Pakistan.
- Saskatchewan Dept. Mineral Resources Rept. -- Province of Saskatchewan, Department of Mineral Resources, Petroleum Lands Branch, Geophysical and Evaluation Division Report. Regina, Saskatchewan, Canada.
- Sierra Leone Geol. Survey Bull. -- Bulletin of the Sierra Leone Geological Survey. Published in London, England, for the Sierra Leone Geological Survey.
- Smithsonian Inst. Misc. Colln. -- Smithsonian Institution, Smithsonian Miscellaneous Collections. Washington, D. C.
- Space Sci. -- Space Science. Benjamin Adelman, Publisher. Silver Spring, Maryland.
- Terra -- Terra [Earth]. Suomen Maantieteellisen Seuran Aikakauskirja (Geografiska Sällskapet i Finland Tidskrift) [Geographical Society of Finland Journal]. Helsinki, Finland.
- Ti Chih Lun P'ing [Geological Review] -- Ti Chih Lun P'ing [Geological Review]. Geological Society of China. Peiping, China.
- Uppsala Univ. Geol. Inst. Bull. -- Bulletin of the Geological Institution of The University of Uppsala. University of Uppsala. Uppsala, Sweden.
- Vrania -- Vrania. Sugranes Hnos., Editores. Tarragona, Spain.
- Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy -- Trudy, Vsesoyuznyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Neftyanoy Institut (VNIGNI) [Transactions, All-Union Scientific Research Geological Exploration Petroleum Institute]. Moskva (Moscow), U. S. S. R.
- West Virginia Geol. and Econ. Survey Rept. Inv. -- State of West Virginia Geological and Economic Survey Report of Investigations. Morgantown, West Virginia.

Form of Citation

The abbreviations of journal titles used are those used in the U.S. Geological Survey publications and in many geological journals. For papers in most languages other than English, the title is given in the original language as well as in translation. Slavic names and titles have been transliterated by the system used by the United States Board of Geographic Names. This system of transliteration for Russian is given in Geophysical Abstracts 148 (January-March 1952, Bulletin 991-A) and in the new "List of Journals" announced above. Titles of papers in Japanese and Chinese are given in translation only.

Abstracters

Abstracts in this issue have been prepared by Henry Faul, Ruth M. Gove, Wanda L. Grimes, and A. J. Shneiderov, as well as by the principal authors. Authors' abstracts are used in many instances. The initials of an abstracter following the notation "Author's abstract" indicates a translation from the original language.

AGE DETERMINATIONS

- 187-1. Rubinshteyn, M. M. O prodolzhitel'nosti Yurskogo perioda [On the length of the Jurassic period]: Akad. Nauk SSSR Doklady, v. 136, no. 6, p. 1432-1435, 1961.

On the basis of 5 K-Ar age determinations on critical samples from the U. S. S. R.—biotites from the Kelasur and Gumista granites and hornblende-biotite fractions from the Khev (Khevisdzhar) quartz diorite—the duration of the Jurassic period is established as $50-60 \times 10^6$ yr, and the lower limit is pushed back to $190-200 \times 10^6$ yr ago. — D. B. V.

- 187-2. Poleyaya, N. I. Shkala absolyutnoy geokhronologii po glaukonitam [Scale of absolute geochronology according to glauconite]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 123-132, 1961.

The results of absolute age determinations on paleontologically dated glauconites are documented, their suitability for absolute dating is demonstrated, and a comparison is made with data obtained for these same intervals of geologic time by other authors. In conclusion, a first variant is presented for the scale of absolute geochronology, compiled on a basis of glauconites and confirmed by data on contemporaneous micas and volcanic rocks. — Author's abstract, J. W. C.

- 187-3. Picciotto, Edgard E. Geochemistry of radioactive elements in the ocean and the chronology of deep-sea sediments, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 367-390, 1961.

In the study of the many types of information to be deduced from cores of deep-sea sediments one particular problem arises, that of fixing a time scale in order to date in an absolute manner the observed phenomena. This paper reviews the present state of research in the field of chronological methods based on radioactive disintegrations and describes the outlook for progress in the near future. The principles of radioactive methods of age determination, the natural radioactive nuclides in the ocean, and the radioactive nuclides present in pelagic sediments are discussed. Possible chronological methods based on the decay of cosmogenic radionuclides, ionium or protactinium, and

growth of ionium and protactinium are described briefly. Various miscellaneous methods are mentioned also. (See also Geophys. Abs. 185-11.)—V. S. N.

- 187-4. Firsov, L. V. Predlozheniye o standartizatsii sistemy publikatsii materialov po absolyutnomu vozrastu [Proposed standardization in the format of publishing absolute age data]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 148-150, 1961.

A uniform system of units for data reporting and constants for age calculation is proposed. Publications should include an adequate geologic discussion of the samples and description of analytical methods and their errors. — H. F.

- 187-5. Kozhina, T. K. Geologo-mineralogicheskaya kharakteristika etalonnoy proby dlya metodicheskikh issledovaniy svyazannykh s opredeleniem absolyutnogo vozrasta (pegmatitovaya zhila no. 9, Chernaya Salma, Severnaya Kareliya) [Geologic-mineralogic characteristics of the reference sample for methodology research in absolute age determination (pegmatite vein no. 9, Chernaya Salma, Northern Karelia)]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 8-19, 1961.

The muscovite-microcline-plagioclase pegmatite vein no. 9 occurs in the plot of the Chernaya Salma deposit, 1 mile northeast of the Chkalov mine in the Loukhov region, in a complex of Byelomoryan age. Clean microcline, biotite, and muscovite were taken from this vein and prepared into reference standards in 1958. About 20 kg of each of the micas was split into sheets about 0.1 to 0.2 mm thick and mechanically sheared into slivers about 3 cm long and 2 mm wide and passed over a sieve with 0.5 mm openings. Rose and grey microcline were selected, crushed, sieved into various size fractions, washed in water, dried at 80°C, and mixed to produce about 20 kg samples of each color and size (1-0.5 mm, 0.5-0.25 mm, and minus 0.25 mm). Optical data, differential thermal analyses, and detailed chemical analyses for the samples are given. — H. F.

- 187-6. Pekarskaya, T. B. O nauchno-issledovatel'skikh rabotakh po probleme "Geokhronologicheskaya Shkala SSSR, vyrazhennaya v absolyutnom letochislenii" [Research on the problem "geochronologic scale of the USSR, expressed in absolute time"]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 20-29, 1961.

Recent geochronological research in the U. S. S. R. is reviewed. — H. F.

- 187-7. Chantret, Francis. Essai de datage de minéraux d'uranium de formation récente par autoradiographie [Attempt at dating of uranium minerals of recent formation by autoradiography]: Acad. Sci. [Paris] Comptes Rendus, v. 253, no. 3, p. 500-501, 1961.

A method of dating uranium minerals is proposed that is based in principle on the ratio (k) of the apparent uranium content, determined by autoradiography, to the true uranium content, determined chemically. A curve is constructed showing k as a function of time. Precision is good to 250,000 yr; the method is therefore applicable to supergene minerals, which are generally recent.

The finely powdered sample is formed into two tablets 5 mm in diameter, one of the pure mineral and the other mixed with 50 percent silica (to deter-

mine the coefficient of absorption of the mineral). After 30 days, during which the radon displaced in grinding should return to equilibrium with radium, the tablets are set on film for a time sufficient to count several thousand alpha-tracks. A series of minerals is now being studied. One of these, an autunite, has given an age of $34,000 \pm 3,000$ yr, which is in good agreement with the age obtained by radiometric analysis of ionium after chemical separation. — D. B. V.

- 187-8. Brodskiy, A. I., and Goldenfeld, I. V. Ob otsenke dostovernosti opredeleniya geologicheskogo vozrasta svintsovyimi izotopnymi metodami [Appraisal of the trustworthiness of geologic age determination by lead isotope methods]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 98-108, 1961.

Chemical and mass-spectrometric errors in the isotopic U-Th/Pb method of age determination are discussed analytically with reference to measurements on the same sample from several laboratories. Pertinent coefficients in the resulting equations are shown in graphs as a function of age or non-radiogenic lead content. — H. F.

- 187-9. Starik, I. Ye., Sobotovitch, E. V., and Lovtsyus, G. P. Pirokhimicheskiye metody vydeleniya svintsa iz prirodnykh obrazovaniy [Pyrochemical methods of extracting lead from natural samples]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 114-127, 1961.

A pyrochemical method of lead analysis of rocks, minerals, and meteorites is described. A horizontal quartz retort with a tapered ground joint containing a water cooled quartz target is placed in a furnace heated by 4-6 silicon carbide rods with a total power input of about 3-6 kw. The sample is placed in a quartz boat and can be heated to about $1,400^{\circ}\text{C}$; however, operation at such a high temperature presents various difficulties, and it is preferable to work around $1,100^{\circ}\text{C}$ - $1,200^{\circ}\text{C}$. Dithizone-cleaned borax containing about 10^{-8} g/g of lead is used as flux. In a few hours at temperatures of $1,000^{\circ}\text{C}$ - $1,200^{\circ}\text{C}$ in hydrogen, lead is released almost completely from such minerals as thorite or cyrtolite; other minerals require more time, and it is almost impossible to release all the lead from monazite or whole granite. Therefore, it is necessary to equilibrate completely the Pb^{212} tracer with the sample by pre-fusing them 3-4 h in a stream of air without the loss of lead. The lead deposited on the target is washed off with nitric acid; the yield is determined by counting the Pb^{212} , and the total lead is determined with dithizone with an error of ± 8 percent. The 3-5 μg necessary for isotopic analysis of lead can be advantageously released from samples by the pyrochemical method without the danger of contamination by atmospheric lead. — H. F.

- 187-10. Karpinskaya, T. B., Ostrovskiy, I. A., and Shanin, L. L. Iskusstvennoye vnedreniye argona v slyudu pri vysokikh davleniyakh i temperaturakh [Artificial introduction of argon into mica at high pressures and temperatures]: Akad. Nauk SSSR Izv. Ser. Geol., no. 8, p. 99-100, 1961.

Natural muscovite ground to 0.2 mm dimensions and also 40×30 mm sheets of the mineral were subjected to temperatures of about 750°C - 850°C and pressures of 3,000-5,000 atm in an atmosphere of argon; the argon content was then determined by means of a mass spectrometer. The results show that appreciable amounts of argon are absorbed, in many cases exceeding the radiogenic argon content, and that the degree of fragmentation evidently plays an es-

essential role in determining the amount absorbed (the powdered muscovite absorbed up to 10 times as much as the laminae). When one of the powdered samples was subsequently heated, it was found that 60 percent of the introduced argon was retained at temperatures up to 520°C. These preliminary results suggest that a significant part of the argon absorbed by mica at high pressure is securely retained by the mineral and enters into the crystal structure, for in the case of surface adsorption the argon should be driven off at low temperatures. — D. B. V.

- 187-11. Firsov, L. V. O vybore konstant razpada kaliya-40 dlya opredeleniya vozrasta porod po otnosheniyu argona-40 k kaliyu-40 [Selection of potassium-40 decay constants for determination of the age of rocks by the argon-40/potassium-40 ratio]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 87-92, 1961.

Western literature is reviewed and adoption of constants essentially identical with those used in the United States is recommended: $\lambda_K = 0.585 \times 10^{-10} \text{yr}^{-1}$, $\lambda_\beta = 4.68 \times 10^{-10} \text{yr}^{-1}$, $R = 1.25$. (See also Geophys. Abs. 182-8.) — H. F.

- 187-12. Rubinshteyn, M. M., Grigoryev, I. G., Uznadze, E. D., and Gel'man, O. Ya. Fotometricheskoye opredeleniye kaliya i natriya v ammiachno-kislородnom plameni [Photometric determination of potassium and sodium in an ammoniac-oxygen flame]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 109-113, 1961.

A flame photometer using a flame of ammonia burning in oxygen is described. Oxygen is introduced in the center of the flame and carries the solution to be analyzed. Ammonia enters the flame from a concentric circle of small holes. The flame has a temperature around 1,720°C as measured with an optical pyrometer. For potassium the 7,665 and 7,699 Å lines are used; a significant interfering effect of sodium concentration on the intensity of the potassium lines is observed and is shown in graphs. Lithium chloride as a radiation buffer, in concentrations up to 10 g/l, does not reduce the interference materially. The calibration curve for sodium, using the 5,890-5,896 Å lines, is flatter than for potassium, and the precision of the sodium determinations is consequently lower. Preliminary results indicate no interference from calcium in concentrations up to 400 mg/l. The method allows quantitative analysis with a maximum relative error of ±5 percent for potassium and ±8 percent for sodium. — H. F.

- 187-13. Aleksandruk, V. M. K voprosu opredeleniya absolyutnogo geologicheskogo vozrasta reniyevym metodom [Determination of absolute geologic age by the rhenium method]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 144-147, 1961.

The western literature on age determinations by the rhenium method is reviewed. — H. F.

- 187-14. Bloom, Arthur L. Late Pleistocene changes of sea level in southwestern Maine: Maine Geol. Survey Rept., 143 p., 1960.

Carbon-14 age determinations on marine shells from Waterville, Maine, indicate that late Pleistocene marine submergence of the coastal plain of southwestern Maine may have been in progress 11,800 yr before present; be-

tween 7,000-8,000 and 4,200 yr before present the coast emerged at least 2 feet and possibly as much as 8-9 feet greater than present. Progressive submergence has continued since then. If eustatic sea level has been near its present position for the past 5,000 yr, as accumulating evidence suggests, then either the isostatic movement of the coast of Maine has reversed its direction, or other tectonic movements are causing coastal subsidence. — V. S. N.

- 187-15. Basset, W. A. Potassium-argon age of Devils Tower, Wyoming: *Science*, v. 134, no. 3487, p. 1373, 1961.

Potassium-argon age determinations on orthoclase phenocrysts from Devils Tower, Wyo., indicate an age of 40.5×10^6 yr ± 4 percent. This is consistent with the geologically accepted Tertiary age. — R. M. G.

- 187-16. Silverman, A., Long, A., and Kulp, J. L[aurence]. Age of Coeur d'Alene mineralization: An isotopic study: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, p. 117-118, 1960; also in *Mining Eng.*, v. 12, p. 470-471, 1960.

The geologic interpretation of the history of the deposits surrounding the Gem stocks in the Coeur d'Alene district, Idaho, are discussed in light of a recent isotopic study of this district. Leads from ten widely scattered mines north and south of the Osburn fault and through a vertical distance of more than 5,000 feet were dated. Also included were galenas from stringers which cut the Gem stocks in various places. Results indicate that the entire mineralization of the Coeur d'Alene-British Columbia base metal belt was derived from a deep source and emplaced in the Precambrian. The Gem stocks area, however, presents geologic relations that may be in conflict with this Precambrian age. The effect of Tertiary and Laramide intrusive activities is discussed, and it is suggested that the Precambrian lead ratios could remain unchanged if the lead of previously existing ore deposits was remobilized during the Laramide and moved rapidly through the crust along pronounced structures to its present position. If the absolute age of mineralization may be determined independently, and geological relations are clearly understood, these data provide a powerful insight into the mechanism of ore deposition and origin of the ore in a given area. — V. S. N.

- 187-17. Karrow, P. V., Clark, J. R., and Terasmae, J. The age of Lake Iroquois and Lake Ontario: *Jour. Geology*, v. 69, no. 6, p. 659-667, 1961.

Recent geological and engineering investigations at Hamilton, Ontario, have resulted in the discovery of buried plant-bearing beds in deposits of Lake Iroquois and Lake Ontario. Fossils in these beds indicate cold, shallow-water conditions of sedimentation for the earlier-deposited beds and warmer conditions for later-deposited layers. Radiocarbon dating of buried wood suggests that Lake Iroquois was formed during the retreat of Port Huron ice. The Valders drift boundary is inferred to the north of Lake Ontario. Lake Ontario probably began over 10,000 yr ago. — Authors' abstract

Larochelle, A. Application of palaeomagnetism to geological correlation. See *Geophys. Abs.* 187-478.

- 187-18. Craig, B[ruce] G. Surficial geology of Northern District of Keewatin, Northwest Territories: *Canada Geol. Survey, Dept. of Mines and Tech. Surveys*, Paper 61-5, 8 p., 1961.

The area encompassed by this report is bounded on the east by the 90th meridian, on the west by the 102d meridian, on the north by the Arctic coast and the Isthmus of Boothia, and on the south by the 66th parallel. The abundant variety of glacial landforms, the pattern of ice-retreat, and the evidence for post-glacial marine submergence are discussed briefly. Radiocarbon ages determined for marine shells from 5 localities range from $8,370 \pm 175$ to $3,690 \pm 120$ yr before present. Data from the 4 highest localities agree with those of Lee (1960) for the east side of Hudson Bay, which show that uplift took place more rapidly in the initial stage than it did toward the end of the period of readjustment. The rates of emergence in the present area are, however, greater than those suggested by Lee. — V. S. N.

- 187-19. Wilson, N. W., and Marmo, V[ladi]. Radiogenic ages, in *Geology, geomorphology, and mineral resources of the Sula Mountains: Sierra Leone Geol. Survey Bull.*, no. 1, p. 26-30, 1958.

The lead-isotope ages were determined for galena and monazite and the K-Ar age for microcline from pegmatite and sericitic quartz veins and alluvium associated with the granite and schist of the Sula Mountains, north of the Pampana River in Sierra Leone. The ages as determined by analysts in separate laboratories and as calculated by Wilson on the one hand and by Geiss on the other are given in tables. Ages adopted for the Dalakuru galena are $2.26 \pm 0.12 \times 10^9$ yr (Wilson) and 2.98×10^9 yr (Geiss). Geiss dates the Yirisen galena as 3.02×10^9 yr. Wilson's monazite age, $2.93 \pm 0.20 \times 10^9$ yr, agrees closely with the Holmes and Cahen age for the Dalakuru galena. Isotopic lead ratios of galenas from veins cutting the Bulawayan of Southern Rhodesia, the Nanzian of the Kenya-Uganda border, and the Sula Mountains schist agree closely; these formations may be approximately contemporaneous. — V. S. N.

- 187-20. Bloomfield, K. The age of the Chilwa alkaline province: *Nyasaland Geol. Survey Rec.*, v. 1, p. 95-100, 1959 (1961).

Recent lead-alpha age determinations on zircon from a typical large plutonic mass of the Chilwa alkaline province in southern Nyasaland and Mozambique indicate a Late Jurassic age, $138 \pm 14 \times 10^6$ yr, for the main plutonic phase of the province. Indirect stratigraphic and other evidence has previously suggested a Liassic or later age for the rocks of the Chilwa province. — V. S. N.

- 187-21. Dewey, J. F. A note concerning the age of the metamorphism of the Dalradian rocks of Western Ireland: *Geol. Mag.*, v. 98, no. 5, p. 399-405, 1961.

Evidence is presented to relate the published minimum absolute date (see Giletti and others, *Geophys. Abs.* 187-22) of 475 million years for the metamorphism of the Connemara schists to a position in the Lower Paleozoic stratigraphy of western Ireland. A Late Cambrian or Tremadocian age is considered likely for the Dalradian metamorphism, since it predates the *Didymograptus extensus* zone of the Arenig in Connemara and South Mayo and post-dates the Leny limestone (lower Middle Cambrian), an integral part of the Scottish Dalradian succession. — V. S. N.

- 187-22. Giletti, Bruno J., Moorbath, Stephen, and Lambert, Richard St. John. A geochronological study of the metamorphic complexes of the Scottish Highlands: *Geol. Soc. London Quart. Jour.*, v. 117, pt. 3, no. 467, p. 233-272, 1961.

Rubidium-strontium age determinations are presented for minerals and whole rocks from the Lewisian, Moinian, and Dalradian metamorphic complexes of Scotland and from the Connemara schists of western Ireland. On the basis of the ages so far measured, the following historical sequence has been constructed for events in the metamorphic and tectonic zones of the Scottish Highlands: (1) the Scourian metamorphism of the Lewisian at a time older than $2,460 \times 10^6$ yr; (2) the Laxfordian metamorphism, which affected most of the Lewisian complex, at about $1,600 \times 10^6$ yr ago; (3) intrusion of the Moinian pegmatites in Knoydart and Morar before 740×10^6 yr ago; (4) intrusion of the Ben Vuroch granite between 700 and 500×10^6 yr ago, giving a lower age limit for the Dalradian sediments; (5) metamorphism of part of the Dalradian sediments and Connemara schists $475 \pm 15 \times 10^6$ yr ago during Early or Middle Ordovician; (6) a Silurian-Early Devonian metamorphism at $420 \pm 15 \times 10^6$ yr ago affecting the Moine Series of the Northern Highlands, and also recorded at Ben Vuroch; and (7) intrusion of Caledonian granitic rocks—the Shap, Leinster, Creetown, Aberdeen, and Galway granites. From the above history it follows that the Torridonian sediments are younger than $1,600 \times 10^6$ yr and possibly less than $1,160 \times 10^6$ yr, and the Caledonian orogeny proper occurred in the Silurian. — V. S. N.

- 187-23. Dodson, Martin Henry. Isotopic ages from the Lizard Peninsula, South Cornwall: Geol. Soc. London Proc., no. 1591, p. 133-136, 1961.

The results of K-Ar age determinations on two samples of mica-schist from the Old Lizard Head Series, one of hornblende-schist from the Landewednack group, and one from the Kennack gneiss in the area of the Lizard Peninsula, Cornwall, England, are reported. The Kennack gneiss was also dated by the Rb-Sr method. The most striking feature of the results is the close grouping of the ages in the range $348-377 \times 10^6$ yr. Not only is there agreement between the K-Ar results on the three varied rock-types but also between the results obtained by the two different methods on the Kennack gneiss. It seems reasonable that the emplacement of the Hercynian granites 270 million years ago had no serious effect on the ages now measured and that the mean value of 360 million years be considered as the approximate date of an important igneous and metamorphic event in the Lizard Peninsula during Middle or Late Devonian time. This event may have been the crystallization of the Kennack gneisses and the Lizard complex as a whole. If the schists of the Old Lizard Head Series are Precambrian their older age was obliterated by this event; if, they are metamorphosed Lower Devonian sediments as suggested by Hendirks (1959), their principal dynamic metamorphism may have been associated with a major event of which the intrusion of the Kennack gneiss was a part. The present isotopic data, however, do not exclude the possibility of a greater age for the intrusive complex. The application of the technique of whole-rock Rb-Sr analysis is suggested for this area. (See also Geophys. Abs. 186-35.) — V. S. N.

- 187-24. Oeschger, H., and Röthlisberger, H[ans]. Datierung eines ehemaligen Standes des Aletschgletscher durch Radioaktivitätsmessung an Holzproben und Bemerkungen zu Holzfunden an weiteren Gletschern [Dating of a former stand of the Aletsch Glacier by radioactivity measurements on wood samples and remarks concerning wood found on other glaciers (with English and French summaries)]: Zeitschr. Gletscherkunde u. Glazialgeologie, v. 4, no. 3, p. 191-206, 1961.

Carbon-14 dating of two samples from ancient tree stumps and roots in the area recently exposed by retreat of the Aletsch Glacier in Switzerland showed

ages of 720 ± 100 and 700 ± 100 yr, indicating that the forest was buried by the advance of the Great Aletsch Glacier about A. D. 1200.

No dating has been attempted on wood collected at the snouts of the Findeln and Ferpècle-Mont Miné Glaciers, as it has been impossible to determine the original site of the forests involved. — D. B. V.

- 187-25. Higazy, Riad A., and El-Ramly, M. F. Potassium-argon ages of some rocks from the Eastern Desert of Egypt: United Arab Republic Geol. Survey and Mineral Research Dept. Paper, no. 7, 18 p., 1960.

Potassium-argon ages are reported for 20 samples from the crystalline basement complex of the Eastern Desert of Egypt. The absolute ages range from 600 to 40 million years or from Eo-Cambrian (Late Precambrian?) to Tertiary. Igneous intrusions and volcanic activity seem to have occurred at the following times (in millions of years): Late Precambrian or Eo-Cambrian, 600-590; Early Cambrian-Ordovician, 470-420; Ordovician-Silurian, 410-340; Silurian-Devonian, 300-285 (corresponds to Caledonian); Late Cretaceous, 80-75; and Tertiary, 55-40 (corresponds to Alpine). Granites of the Eastern Desert previously assigned to Metarcean and Late Precambrian are now proved to be Late Precambrian and Early Cambrian-Ordovician, respectively. Detailed results are given in tables. — V. S. N.

- 187-26. Brotzen, F. An interstadial (radiocarbon dated) and the substages of the last glaciation in Sweden: Geol. Fören. Stockholm Förh., v. 83, no. 2, p. 144-150, 1961.

Radiocarbon dating of core samples from Ingebäck, 12 km north of Gothenberg, and from the Hisinge tunnel excavation in Gothenberg gave two groups of dates—20,000-30,000 yr and 10,000-16,000 yr; the older is related to a hitherto unknown marine interstadial and the younger to lateglacial and postglacial sediments. The differences between the two groups is always more than 10,000 yr, demonstrating that below about 55 m depth there is a large break in sedimentation. Possible correlations are discussed. — D. B. V.

- 187-27. Semenenko, N. P. Opredeleeniye vozrasta metamorficheskikh slantsev dokembriya Shvetsii kaliy-argonovym metodom [Age determination on Precambrian schists from Sweden by the potassium-argon method]: Akad. Nauk SSSR, Kom. Opredeleeniya Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 56-58, 1961.

Whole-rock K/Ar age determinations on 9 samples of slate, schist, and gneiss from Sweden are reported and three periods of metamorphism are proposed. (See also Geophys. Abs. 185-47.) — H. F.

- 187-28. Liiva, A. A. Opredeleeniye absolyutnogo vozrasta radiouglerodnym metodom (v Estonii) [Determination of absolute age by the radiocarbon method (in Estonia)]: Geokhimiya, no. 8, p. 710-712, 1961.

Radiocarbon dating in Estonia began in 1957. The method used, a variant of Pringle's (1957) scintillation method, is described. So far, a series of archeologic samples from the Neolithic settlements at Klyap have been dated; results will be published separately. — D. B. V.

- 187-29. Komlev, L. V., Mikhalevskaya, A. D., and Danilevich, S. I. O vozraste shchelochnykh intruziy Khibinskikh i Lovozerskikh tundr (Kol'skiy poluoostrov) [On the age of the alkaline intrusions of the

Khibin and Lovozero tundras (Kola Peninsula): Akad. Nauk SSSR Doklady, v. 136, no. 1, p. 172-174, 1961.

The average age of minerals from two alkaline intrusions in the Khibin and Lovozero tundras in the Kola Peninsula, dated by the lead isotope method, is $290 \pm 10 \times 10^6$ yr; this is in good agreement with the age of 300×10^6 yr obtained by Gerling and others (1949) by the K-Ar method (recalculated using the new constants). — D. B. V.

- 187-30. Bespalova, I. D., and Semenov, E. I. Ob absolyutnom vozraste Lovozerskogo i drugikh shchelochnykh massivov Kolskogo poluostrova [Absolute age of the Lovozero and other alkaline massifs of the Kola Peninsula]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 77-80, 1961.

The ages of several minerals of the thorite group from Lovozero, Khibiny, Keyby, and Afrikanda in the Kola Peninsula were determined by the X-ray spectrometric (total lead) method. The results range from 312 to 400×10^6 yr; most are clustered around 380×10^6 yr. A galena from a pegmatite in Khibiny has the lead isotopic composition 1:18.17:15.40:39.0. — H. F.

- 187-31. Maslenikov, V. A., Bondarenko, L. P., and Dagelayskiy, V. B. Drevneyshiye gornyye porody Kol'skogo poluostrova [Ancient rocks of the Kola Peninsula]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 133-155, 1961.

A geologic-petrographic description is presented of the ancient rocks of the Kola Peninsula; these are divided into two groups. The first group consists of gneissic granites, granites, migmatites, and pegmatites, and the K-Ar ages range from 3,600 to $3,060 \times 10^6$ yr. The second group consists of gneisses, granites, pegmatites, amphibolites, and pyroxenites, and the K-Ar ages range from 2,880 to $2,700 \times 10^6$ yr. These rocks are referred to the lower and upper divisions, respectively, of the Katarchean. — Authors' abstract, J. W. C.

- 187-32. Priyatkina, L. A. Ritmichnaya sloistost' v arkhayskikh porodakh Kol'skogo poluostrova [Rhythmic bedding in the Archean rocks of the Kola Peninsula]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 156-165, 1961.

Rhythmic bedding in Archean conglomerates of the Kola Peninsula is described. The age of the metamorphic unit is $2,600-2,200 \times 10^6$ yr, but the age of the granite pebbles within the conglomerate is $3,180 \times 10^6$ yr. — J. W. C.

- 187-33. Dagelayskiy, V. B. Razval'tsovannyekonglomeraty severo-zapadnoy chasti svity polmos (Kol'skiy poluostrov) [Laminated conglomerates of the northwest part of the Polmos formation (Kola Peninsula)]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 166-175, 1961.

Argon age determinations were made on a laminated conglomerate of the Polmos formation. A biotite granite gneiss (cement of the conglomerate) gives $2,310 \times 10^6$ yr, a two-mica schist $-2,300 \times 10^6$ yr, and biotite plagiogranite pebbles $-2,780 \times 10^6$ yr. — J. W. C.

- 187-34. Polkanov, A. A., and Li-Zhen', U. O genezise i evolyutsii shchelochnoy magmy Khibinskogo subvulkana [Genesis and evolution of

the alkaline magma of the Khibin subvolcano]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 176-186, 1961.

A physicochemical analysis is presented for the Khibin comagmatic series of the Kola Peninsula, and a new date of $290 \pm 10 \times 10^6$ yr is given. — J. W. C.

- 187-35. Lobach-Zhuchenko, S. B., and Pinayeva, N. I. Ob absolyutnom vozrast i kharaktere kontaktov porod arkheya i nizhnego proterozoya (yuzhnaya Kareliya) [On the absolute age and character of contacts of rocks of the Archean and lower Proterozoic (southern Karelia)]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 187-211, 1961.

Study of the structure, metamorphism, and geochronology of the metamorphic rocks of southern Karelia has demonstrated that a zone of lower Proterozoic rocks contains Archean formations that have not been reworked by later metamorphism. The Archean rocks are $2,200-2,700 \times 10^6$ yr old and are correlated with the Saamides. The lower Proterozoic rocks are $1,700-1,950 \times 10^6$ yr old and are referred to the early Karelides. — J. W. C.

- 187-36. Glebova-Kul'bakh, G. O., and Pinayeva, N. I. Novyye dannyye po geologii i geokhronologii rayona Gormozera v yuzhnoy Karelii [New data on the geology and geochronology of the Gormozher region in southern Karelia]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 212-237, 1961.

The Gormozher region of south Karelia A. S. S. R. is underlain by metamorphosed geosynclinal sediments and volcanic rocks and by granites. Two stages of metamorphism are recognized. A regional metamorphism accompanied by folding and intrusion of granite is dated at $1,900-1,870 \times 10^6$ yr. A regressive metamorphism is dated at $1,740 \times 10^6$ yr. Faulting following the second metamorphism took place at $1,670 \times 10^6$ yr on a basis of biotite in the fault breccia. Anomalous figures were obtained on muscovite from pegmatite ($2,400 \times 10^6$ yr), greisen ($2,200 \times 10^6$ yr), and schist ($2,430 \times 10^6$ yr). — J. W. C.

- 187-37. Borisova, K. D., Gorokhov, I. M., and Lobach-Zhuchenko, S. B. Aktsessornyye mineraly metasomaticheskii preobrazovannykh arkheyskikh granito-gneysov [Accessory minerals of metasomatically altered Archean granite gneisses]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 238-256, 1961.

Migmatization of Archean plagioclase granitic gneisses accompanied by growth of new accessory minerals in Karelia is described. Determinations of the absolute age of the various minerals yields three groups of figures: $3,050-2,660 \times 10^6$ yr, $2,500-2,200 \times 10^6$ yr, and $1,800-1,400 \times 10^6$ yr. The first group of figures is the age of the formation. The third group corresponds to the time of recrystallization, giving rise to a "rejuvenation" of the age. The second group of figures is intermediate and is not as yet explained satisfactorily. — Authors' abstract, J. W. C.

- 187-38. Polkanov, A. A., and Gerling, E. K. Geokhronologiya i geologicheskaya evolyutsiya Baltiyskogo shchita i yego skladchatogo obramleniya [Geochronology and geologic evolution of the Baltic shield and its folded frame]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 7-102, 1961.

On a basis of about 600 age determinations on Precambrian, Caledonian, and Hercynian rocks of Karelia, the Kola Peninsula, Finland, Norway, and Sweden, a synthesis is presented of the geologic development of the Baltic shield and adjacent areas. The ages range from Katarchean at $3,590 \times 10^6$ yr to Cambrian at $600-400 \times 10^6$ yr. Each geochronological subdivision is discussed, and the pertinent age data are tabulated. — J. W. C.

- 187-39. Polevaya, N. I., and Kazakov, G. A. Vozrastnoye raschleneniye i korrelyatsiya drevnikh nemykh otlozheniy po otnosheniyu Ar^{40}/K^{40} v glaukonitakh [Age differentiation and correlation of ancient unfossiliferous rocks according to the ratio Ar^{40}/K^{40} in glauconites]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 103-122, 1961.

On the basis of absolute age determinations on about 50 specimens of glauconite from unfossiliferous sediments of the Russian and Siberian platforms and the Urals, it is demonstrated that formation of the Sinian sediments (Late Precambrian) lasted at least about 600×10^6 yr. The upper boundary of the Late Precambrian is placed at $600-500 \times 10^6$ yr. The lower boundary is drawn at the base of the Kaverin formation on the Russian platform, along the pre-Zil'merdak break in the Urals, and at the break between the Uchursk and Maysk series on the Siberian platform; it is determined at $1,200-1,100 \times 10^6$ yr. — Authors' abstract, J. W. C.

- 187-40. Starik, I. Yr., Krylov, A. Ya., and Silin, Yu. I. Absolyutnyy vozrast porod fundamenta vostochnoy chasti Russkoy platformy [Absolute age of the basement rocks of the eastern part of the Russian platform]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 64-65, 1961.

Potassium-argon age determinations on cores taken in exploratory boreholes on the Russian platform give the first insight into the chronology and structure of the region. Of 13 samples analyzed, 1 gives an age of $1,030 \times 10^6$ yr and the remaining 12 give ages between $1,400$ and $1,800 \times 10^6$ yr. — H. F.

- 187-41. Rubinshteyn, M. M. O vremeni formirovaniya kristallicheskogo substrata Kavkaza [Time of formation of the crystalline basement of the Caucasus]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 59-63, 1961.

Potassium-argon age determinations on whole-rock samples give ages that are approximately 30 percent too low. Considering only K/Ar determinations on micas and referring to the Holmes-Marble time scale, it is concluded that the crystalline basement rocks of the Caucasus formed in Late Caledonian and partly in Hercynian time, about $400-250 \times 10^6$ yr ago. If Precambrian rocks are present at all, they could be only latest Precambrian. — H. F.

- 187-42. Rubinshteyn, M. M. O vozraste kristallicheskogo substrata Kavkaza [On the age of the crystalline substratum of the Caucasus]: Akad. Nauk Gruzin. SSR Soobshch., v. 24, no. 2, p. 181-187, 1960.

The argon ages of mica-bearing metamorphic rocks from the oldest geologic units in the Caucasus lie between 220 and 385 million years. — A. J. S.

- 187-43. Adamiya, Sh. A. O vozraste "molodykh" granitov khramskogo kristallicheskogo massiva [Age of the "young" granites of the Khrami crystalline massif]: Akad. Nauk Gruzin. SSR Soobshch., v. 21, no. 4, p. 439-442, 1958.

The geologic age of the granitic intrusions of the middle course of Khrami River in the Caucasus is in agreement with the absolute age determined for potassium feldspar from the pegmatite fraction. — A. J. S.

- 187-44. Ivanov, A. I., Monich, V. K., and Zamyatin, N. I. Absolyutnyy vozrast granitoidnykh intruziy yuzhnoy chasti tsentral'nogo Kazakhstana [Absolute age of granitic intrusions of the south part of central Kazakhstan]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 30-47, 1961.

Potassium-argon age determinations on 53 micas, potassium feldspars, and whole-rock samples and helium age determinations on 3 garnets and 1 magnetite from the Akzhal-Aksoran belt and the Kounradski, Sayak, and Batystau-Bayanazar regions range from about 200 to 550×10^6 yr. Pre-Hercynian (415 – 550×10^6 yr) intrusions occur in the Akzhal-Aksoran belt as geoanticlinal rises on the border of the Dzhungaro-Balkhash Hercynian province and partly as huge xenoliths included in Hercynian rocks. The largest Early Hercynian (Late Devonian or Early Carboniferous) intrusives occur in the Gul'shad region (380×10^6 yr) and in the Balkhash tonalitic complex (about 400×10^6 yr). The late Early or early Middle Carboniferous granodioritic intrusions of the Sayak and Topar complexes give ages around 350 – 370×10^6 yr in the Shetska and Kounradski regions and 330×10^6 yr in the Akzhal-Aksoran belt. Many large granitic intrusions show similar ages. The many Late Hercynian leucocratic granites of the Akchatau complex give ages around 300×10^6 yr, and the Ortau massif is still younger, about 250 – 260×10^6 yr. — H. F.

- 187-45. Firsov, L. V. O vozraste zolotorudnogo mestorozhdeniya Vostochnoe v svyazi s opredeleniyami absolyutnogo vozrasta izveshennykh porod intruziva Khatynnakh v bassejne Kolymy [Age of the Vostochnoe gold deposit in connection with absolute age determinations on igneous rocks of the Khatynnakh intrusive in the Kolyma Basin]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 48-55, 1961.

The Vostochnoe deposit lies between the Khatynnakh and Mylga Rivers, near the south end of the Khatynnakh granodioritic intrusive in contact-metamorphosed sedimentary rocks of Triassic and Jurassic age. Potassium-argon age determinations on three rock types from the intrusive give 100, 105, and 135×10^6 yr. Potassium was measured by the chloroplatinate method, and argon was determined volumetrically with the background of atmospheric argon determined by blank analyses. — H. F.

- 187-46. Firsov, L. V. Opyt parallelnogo opredeleniya absolyutnogo vozrasta redkometalnoy kvartsevo-polevoshpatovoy zhily po $\text{Ar}^{40}/\text{K}^{40}$ i $\text{He}^4/\text{Th}^{232}$ [Experiment at parallel determination of the absolute age of a rare-metal quartz-feldspar vein according to $\text{K}^{40}/\text{Ar}^{40}$ and $\text{He}^4/\text{Th}^{232}$]: Akad. Nauk SSSR, Kom. Opreddeniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 81-86, 1961.

A McLeod system for parallel volumetric determination of argon and helium is described together with details of analytical procedure and calculation of results. A whole-rock sample consisting of quartz, rose-brown feldspar, monazite, chevkinite, and yttrialite from a vein in northeastern Yakutsk A. S. S. R. gives ages of 190×10^6 yr by K/Ar and 174×10^6 yr by Th/He with no correction for air argon. — H. F.

- 187-47. Zykov, S. I., Stupnikova, N. I., Pavlenko, A. S., Tugarinov, A. I., and Orlova, L. P. Absolyutnyy vozrast intruziy Vostochno-Tuvinskogo regiona i Yeniseyskogo kryasha [Absolute age of intrusions in the East Tuva region and the Yenisei Range]: *Geokhimiya*, no. 7, p. 547-560, 1961.

The results of lead isotope age determinations on about 20 uranium-thorium minerals from intrusives in the Agash, Balyktygzhem, and Dugdin massifs and about 20 from other massifs in eastern Tuva are tabulated, together with results obtained on 25 galenas from intrusions in eastern Tuva and 7 monazites from the Tarak intrusion in the Yenisei Range. Thorianite proved to be useful for dating purposes.

The alkaline intrusives of eastern Tuva fall into two age groups, post-Caledonian ($390-430 \times 10^6$ yr) and Variscan (290×10^6 yr). The results on the Tarak massif confirm its Late Archean age ($1,800 \times 10^6$ yr) and also show evidence of intensive hydrothermal metamorphism about $400 \pm 50 \times 10^6$ yr ago. — D. B. V.

- 187-48. Sudovikov, N. G., and Neyelov, A. N. O vozraste stanovogo kompleksa [Age of the Stanovoi complex]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 257-280, 1961.

The Aldan shield is underlain by Archean (Aldan and Stanovoi complexes), Proterozoic, Paleozoic, and Mesozoic rocks. The absolute age of the Aldan complex is greater than $2,400-2,200 \times 10^6$ yr (U-Th-Pb and K-Ar methods), and that of the Stanovoi complex is $1,900 \pm 100 \times 10^6$ yr (K-Ar, Rb-Sr, and U-Th-Pb methods). The K-Ar ages for the rocks of the Aldan complex indicate a widespread manifestation of the phenomenon of "rejuvenation" during late Archean (Stanovoi) time. Along the margins of the shield the Archean rocks have been rejuvenated locally by diaphoresis of Proterozoic ($1,450-1,300 \times 10^6$ yr) and Mesozoic ($200-170 \times 10^6$ yr) age.

To the south in the Stanovoi Range all Precambrian formations have been subjected to regional rejuvenation during the Mesozoic ($219-123 \times 10^6$ yr). This was not accompanied by mineralogical changes, and the structure of the rocks was preserved. Argon appears to diffuse from mica without disrupting the crystal structure under conditions corresponding to the epidote amphibolite facies (about 300°C). — J. W. C.

- 187-49. Velikoslavinskiy, D. A., Kazakov, A. N., and Gerling, E. K. K voprosu o vozraste geologicheskikh obrazovaniy Severo-Baykalskogo nagor'ya [Problem of the age of geological formations of the north Baikal highlands]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 281-290, 1961.

Four age groups are recognized in the highlands of north Baikal: (1) Muiyskaya and Chuyskaya series invaded by granite at $1,500-1,100 \times 10^6$ yr; (2) Zherbinskaya formation deposited at $550-500 \times 10^6$ yr, and Patomskaya series metamorphosed at $360-350 \times 10^6$ yr; (3) Mamskaya and Teptorginskaya series metamorphosed at $400-300 \times 10^6$ yr; and (4) postorogenic granites and aenites of the Mamskaya field intruded at $250-230 \times 10^6$ yr. Data for each age group are presented in tables and discussed, and a synthesis of the geologic history is compiled. — J. W. C.

- 187-50. Savel'yev, A. A. O vozraste skladchosti, magmatizma i metamorfizma v proterozoye tsentral'noy chasti Vostochnogo Sayana [Age of the folding, magmatism, and metamorphism in the Proterozoic of the central part of the east Sayan]: *Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy*, no. 12, p. 291-298, 1961.

Geological and geochronological data are presented for geosynclinal and orogenic activity during the Proterozoic and Cambrian in the central part of the east Sayan. Age data are tabulated for gneisses, granites, marbles, and metamorphosed clastic rocks of the east Sayan anticlinorium; they range from 415 to 542×10^6 yr. — J. W. C.

- 187-51. Khil'tova, V. Ya. Metamorfizm Biryusinskoy i Derbinskoy seri yego absolyutnyy vozrast [Metamorphism of the Biryusinskiy and Derbinskiy series and its absolute age]: Akad. Nauk SSSR Lab. Geologii Dokembriya Trudy, no. 12, p. 299-313, 1961.

Regional and retrogressive metamorphisms have been established for the Biryusinskiy series of the Sayan Range. The K-Ar ages range from 460 to 670×10^6 yr and correspond in general to the time of the retrogressive alteration. Only one stage of metamorphism is distinguished in the Derbinskiy series; it is dated at 450 - 500×10^6 yr. — J. W. C.

- 187-52. Starik, I. Ye., Baranovskaya, N. V., Zhirova, V. V., and Krylov, A. Ya. Opreddeniye vozrasta magnetitov gelievym metodom [Determination of the age of magnetites by the helium method]: Akad. Nauk SSSR, Kom. Opreddeniye Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 151-159, 1961.

Radium and thorium are determined radiochemically, and helium is released (by dissolving the magnetite in HCl in a CO₂ atmosphere) and measured in a McLeod gauge. Magnetites from placers of the Khiloksky region (Transbaykal) and samarskite and fergusonite from pegmatite veins, all presumed to be Triassic on geologic grounds, give helium ages of 150 - 190×10^6 yr. The total-lead (X-ray spectroscopy) age of the fergusonite is 190×10^6 yr. Magnetite from the Bukhtarminsky deposit (Altay) gives 225 and 255×10^6 yr, magnetite from a placer in the Ubino-Byeloretskiy massif gives 375×10^6 yr, magnetites from placers in the right tributaries of the Byelaya Uba River (Lineyskiy granite) give 275 and 340×10^6 yr (Caledonian), and magnetites from five lake and river placers in the Tien Shan (from the Caledonian granites of the Terskey and Kungey Alatau) give 290 - 480×10^6 yr. Placer magnetite offers new possibilities for age determination, but magnetites that have suffered partial martitization, hematitization, or limonitization are not suitable for age work. — H. F.

- 187-53. Starik, I. Ye., and Zharkov, A. P. Skorost' osadkonakopleniya v Indiskom okeane po dannym radiouglerodnogo metoda [Rate of sedimentation in the Indian Ocean according to data of the radio-carbon method]: Akad. Nauk SSSR Doklady, v. 136, no. 1, p. 203-205, 1961.

Ocean floor sediments from two horizons at each of several stations in different parts of the Indian Ocean were dated by the C¹⁴ method. Ages range from $2,900 \pm 200$ to $34,500 \pm 200$ yr, and sedimentation rates, calculated from these values and thicknesses, range from 0.3 to 2.9 cm per $1,000$ yr. Rates are different for the upper and lower horizons, in most cases being greater for the lower. The rate of sedimentation evidently depends on distance from the coast and from the mouth of the Ganges River. (See also Geophys. Abs. 184-591.) — D. B. V.

- 187-54. Inoue, Hideo, and Sato, Kazuo. Mode of occurrence and absolute age of uraninite from Ryuen mine, Fukuoka Prefecture [in Japanese with English abstract]: Japanese Assoc. Mineralogists, Petrologists, Econ. Geologists Jour., v. 46, no. 4, p. 133-137, 1961.

The U-Pb age of uraninite from a pegmatite intruding the Middle Cretaceous Masaki granite at the Ryuen mine, Fukuoka Prefecture, was determined previously as 100×10^6 yr by Kimura and Iimori (1937). A recent determination on uraninite from a chlorite vein cutting the pegmatite gives an age of 110×10^6 yr. This suggests that the chlorite vein formed immediately after solidification of the pegmatite. — V. S. N.

- 187-55. Searle, E. J. The age of the Auckland volcanoes: New Zealand Geographer, v. 17, no. 1, p. 52-63, 1961.

Radiocarbon dating of wood, charcoal, and shells associated with volcanic deposits of the Auckland area indicates that volcanic activity dates back more than 40,000 yr. A realistic estimate for the span of intermittent activity would be 60,000-70,000 yr; during that period eruptions occurred from at least 50 centers. The last eruption (Rangitoto A. D. $1,188 \pm 50$) less than 1,000 yr ago suggests that further eruptions may be expected to occur in the area. An age classification based on field evidence as well as C^{14} dates is presented: volcanoes older than 50,000 yr, volcanoes with C^{14} dates $> 20,000$ yr, volcanoes $< 20,000$ yr, and historic volcanoes (Rangitoto). — V. S. N.

- 187-56. Deutsch, Sarah, Picciotto, E[dgard] E., and Reinhartz, M. Age measurements on Antarctic rocks (Queen Maud Land): Nature, v. 191, no. 4795, p. 1286-1287, 1961.

The last major metamorphic episode in Queen Maud Land is dated at approximately 475×10^6 yr by the Rb-Sr method on biotite from igneous and metamorphic rocks. Twelve determinations range from 455 to 506×10^6 yr. A half life of 50×10^9 yr was used. — R. M. G.

COSMOGONY

- 187-57. Lyttleton, R. A. An accretion hypothesis for the origin of the solar system: Royal Astron. Soc. Monthly Notices, v. 122, no. 5, p. 399-407, 1961.

Direct accretion of interstellar matter by the sun is considered as a possible source of material for a solar disk as the initial stage of planet formation. The existing mass and angular momentum require a size and density of the cloud in close agreement with observed values. The hypothesis would allow an origin for the planetary material quite separate from the sun and also would imply that a large proportion of old stars may have attendant planets. A disk so formed would appear quite as suitable a source for planets as one relying on magnetic coupling to the sun for its formation. — D. B. V.

- 187-58. Gilbert, C. Dirac's cosmology: Nature, v. 192, no. 4797, p. 57, 1961.

It is pointed out that the assumptions made in the theories of Egged (see Geophys. Abs. 182-58, -59) and Hédervári are not necessarily associated only with the values of Hubble's constant (H) and the acceleration parameter (q) obtained by Gilbert (see Geophys. Abs. 182-281) on the basis of Dirac's cosmology. Other values may be obtained from a different description of the Dirac model in Riemannian space-time. Empirical values of H and q may soon be sufficiently accurate to permit a choice between models. — D. B. V.

- 187-59. Dicke, R. H. Dirac's cosmology and Mach's principle: Nature, v. 192, no. 4801, p. 440-441, 1961.

Dirac, P. A. M. Dirac's cosmology and Mach's principle: *ibid*, p. 441, 1961.

Dicke considers that there is a fundamental relation between the cosmological number that determines the gravitational constant and the number of particles in the universe, following from Mach's principle, but that the cosmological number which determines the Hubble age of the universe is independent; therefore, the first two maybe constant while the third varies with time. He shows that this third number would have roughly its present value when habitable planets exist.

Dirac points out that in Dicke's view habitable planets could exist only for a limited period, whereas with his own assumption that the relationships of the three cosmological numbers correspond to something fundamental in nature (so that when the last varies with time the others would also vary) habitable planets could exist indefinitely. — D. B. V.

187-60. Claus, George, and Nagy, Bartholomew. A microbiological examination of some carbonaceous chondrites: *Nature*, v. 192, no. 4803, p. 594-596, 1961.

Microscopic particles resembling fossil algae were found to be present in relatively large quantities in the Orgeull and Ivuna carbonaceous meteorites. No such particles were found in two ordinary stone meteorites (Holbrook and Bruderheim). The five types of organized elements observed so far are described. It is suggested that these may be microfossils indigenous to the meteorite. — D. B. V.

187-61. Öpik, Ernst J. Meteorite impact life on earth: *Space Sci.*, v. 10, no. 1, p. 2-7, 1960.

The larger members of the interplanetary host of stray bodies that might possibly collide with the earth, asteroids of the Apollo group and comet nuclei, are discussed. From statistical analysis of observational data and from the mathematical theory of collisions, the expected number of asteroids and comet nuclei that may have hit the earth during its lifetime of 4.5 billion years has been calculated and results are given in a table. It appears that projectiles exceeding 4 km in diameter must have fallen 70 times; each was able to extinguish land life over an area equal to that of the United States. Catastrophes of hemispherical extent could have occurred 4 times, a global one perhaps once. These statistics also apply to the future. The expected frequency of collisions, however, seems to be low enough to permit continuous development of life for several hundred million or even a billion years. The surface of the moon is discussed as an observational check on the calculations. A similar calculation is given for Mars where the development of life would be interrupted roughly every 900 million years. — V. S. N.

187-62. Mason, Brian. Meteorites: *Jour. Geography* [Tokyo], v. 70, no. 4 (723), p. 193-198, 1961.

Current knowledge concerning the composition and texture of the three types of meteorites, the frequency of falls and finds, and the origin of meteorites are reviewed. (See also *Geophys. Abs.* 181-53, 183-52.) — V. S. N.

187-63. Mason, Brian. Reply to Dr. Harold C. Urey's criticism of the paper by Brian Mason, "The origin of meteorites": *Jour. Geophys. Research*, v. 66, no. 11, p. 3979-3980, 1961.

In his criticism of Mason's paper (see *Geophys. Abs.* 183-52, 185-80) Urey postulated a constant composition for the material from which the meteorites were formed, and a closed system throughout. Mason points out that there seems to be no factual evidence for either postulate.

It is difficult to produce decisive evidence for a clear-cut decision whether carbonaceous chondrites were derived from olivine-pyroxene chondrites or vice versa. If the carbonaceous chondrites were formed as suggested by Urey, however, chondrules of serpentine pseudomorphous after olivine or pyroxene should be found; but the chondrules that are found are of olivine or pyroxene and appear to have replaced serpentine of the matrix. The sequence appears to be Type I carbonaceous chondrites (no chondrules) → Type II carbonaceous chondrites (chondrules forming by decomposition of serpentine) → Type III carbonaceous chondrites (serpentine completely converted to olivine and pyroxene). — D. B. V.

- 187-64. Hayakawa, T., Hintenberger, H., and Wänke, H. Über die Häufigkeiten der durch die kosmische Strahlung in einigen Eisenmeteoriten produzierten Helium- und Neon-Isotope [On the abundances of the helium and neon isotopes produced by cosmic radiation in some iron meteorites]: *Zeitschr. Naturforschung*, v. 16a, no. 8, p. 844, 1961.

The neon helium contents of the Clark County, Thunda, Treysa, Carbo, and Bendego iron meteorites were reported earlier (see *Geophys. Abs.* 175-257). Their isotopic abundances are tabulated here, along with some corrections to values given in the earlier paper.

The $\text{He}^3/\text{Ne}^{21}$ ratio shows a systematic inverse relation to meteorite mass, and is presumably a depth effect of He^3 . — D. B. V.

- 187-65. Malmqvist, David. Der Meteoritenfall von Hökmark am 9. Juni 1954 [The meteorite fall of Hökmark on June 9, 1954]: *Uppsala Univ. Geol. Inst. Bull.*, v. 40, p. 95-117, 1961.

A meteorite fall on June 9, 1954 at Hökmark, Sweden, is described. Two fragments of stone meteorite were found; one weighs 196.7 g and has a specific gravity of 3.55, and the other weighs 108.8 g and has a specific gravity of 3.57. A man picked up one of the fragments some 10-20 sec after it fell (it nearly struck him), and it felt neither warm nor cold to the touch. — J. W. C.

- 187-66. L'vov, Yu. A., Vasil'yev, N. V., Osharov, A. B., Trukachev, G. A., and Yeroshkina, A. I. Proverka odnoy gipotezy (Svyazau li vyral lesa v bassejne reki Ket'i s padeniyem Tungusskogo meteorita?) [Examination of an hypothesis (Is the forest fall in the basin of Ket River related to the fall of Tungus meteorite?): *Priroda*, no. 7, p. 98-99, 1961.

The explanation that the strip of fallen forest 40 km long and up to 4 km wide along the right bank of Ket River was caused by the fall of Tungus meteorite is challenged. By questioning 80 persons who live in the area, it was found that the fall was caused by two storms: one between 1904 and 1912, and the other between 1923 and 1928. — A. J. S.

- 187-67. Kirova, O. A. O mineralogicheskom izuchenii prob pochv iz rayona padeniya Tungusskogo meteorita, sobrannykh ekspeditsiei 1958 g. [On the mineralogical study of soil samples from the region of fall of the Tungus meteorite, collected by the expedition of 1958]: *Akad. Nauk SSSR Meteoritika*, no. 20, p. 32-39, 1961.

A mineralogical study was made of soil samples taken from a 1,000 km² area of the fall region of the Tungus meteorite. About 90 soil samples from 5 cm deep were studied. Washed soil samples were investigated for nickel content, traces of which (about 0.1 percent) were found in some particles of the magnetic fraction. No minerals of meteoritic origin were found. (See also Geophys. Abs. 184-106.) — A. J. S.

- 187-68. Alexander, W. M. McCracken, C. W., and LaGow, H. E. Interplanetary dust particles of micro-size probably associated with the Leonid meteor stream: *Jour. Geophys. Research*, v. 66, no. 11, p. 3970-3973, 1961.

The dust-particle sensor on the Vanguard III (1959 η) satellite revealed an interval of unusual interplanetary dust particle activity. The important details of the event are reported. It is suggested that these particles could have come from the Leonid meteor stream. The need for more sophisticated dust particle sensors on oriented satellites in studying such activity (at particle size for which ground-based observations are not possible) is mentioned in conclusion. — D. B. V.

- 187-69. Singer, S. F. Interplanetary dust near the earth: *Nature*, v. 192, no. 4800, p. 321-323, 1961.

Theoretical calculations of gravitational accretion of interplanetary dust lead to the prediction that there is a maximum dust concentration at about 2,000-3,000 km above the earth's surface. This dust forms a modest shell around the earth rather than being characterized by a variation with a factor of 10^3 - 10^5 increasing uniformly without a maximum. Experimental data so far available are too scanty to permit firm conclusions about the presence or absence of such a shell. — D. B. V.

- 187-70. McCracken, C. W., Alexander, W. M., and Dubin, M[aurice]. Direct measurement of interplanetary dust particles in the vicinity of earth: *Nature*, v. 192, no. 4801, p. 441-442, 1961.

A series of corrections have been completed that allow results from seven successful high-altitude rockets to be used in quantitative discussions of interplanetary dust particles. Preliminary results, including a new curve for mass distribution and spatial density, are presented here.

An interesting consequence of the new curve is that the influx rate of interplanetary dust is approximately 10^4 tons per day onto the earth; this means that dust particles in the direct-measurements range of particle size dominate the accretion process. — D. B. V.

- 187-71. Dietz, Robert S. Astroblemes: *Sci. American*, v. 205, no. 2, p. 51-58, 1961.

The record of meteorite bombardment preserved on the face of the moon plainly suggests that the list of scars on the earth's surface should be much longer than the 14 well-certified meteorite craters now known. A few "fossil" craters have shown up on aerial photographs, and geological maps of surface and subsurface rock formations have revealed still other circular features that have been generally attributed to volcanic explosions. It now appears that many of the latter are root structures of ancient meteorite craters, and the term "astrobleme" is proposed for those that prove to be obliterated meteorite craters (see also Geophys. Abs. 182-68). At the site of a

suspected astrobleme, evidence of sudden extremely intense shock waves should be sought. Two conclusive pieces of evidence of shock waves of this kind are: (1) conical fractures in rocks known as shatter cones, and (2) coesite, which is created under extremely high pressure. Shatter cones associated with well-known craters such as Barringer in Arizona and the Vredefort Ring in the Transvaal of South Africa are discussed, and those in other structures such as the Wells Creek Basin, Tenn.; the Sierra Madera, Tex.; and Serpent Mound, Ohio, are described. The five sites where coesite has been sought and found—Barringer Crater, Ries Kessel (Germany), Wabar Craters (Arabia), Ashanti Crater, and the Teapot Ess Crater at the Nevada Proving Grounds where the mineral was created by an atomic blast—are discussed. A history of the development of the Vredefort Ring structure is proposed and illustrated. — V. S. N.

- 187-72. Cohen, Alvin J., Bunch, Ted E., and Reid, Arch. M. Coesite discoveries establish cryptovolcanics as fossil meteor craters: *Science*, v. 134, no. 3490, p. 1624-1625, 1961.

Discovery of coesite in St. Peter sandstone from the central uplift of the Kentland structure, Newton County, Ind., and in shatter cones of Lilley dolomite of Middle Silurian age from the central uplift of the Serpent Mound structure near Sinking Springs, Ohio, proves that shatter cones are evidence of meteorite impact. — Authors' abstract

- 187-73. Bjork, R. L. Analysis of the formation of Meteor Crater, Arizona: a preliminary report: *Jour. Geophys. Research*, v. 66, no. 10, p. 3379-3387, 1961.

A theoretical study of the cratering process accompanying the impact of a 12,000-ton iron projectile on a semi-infinite half space of soft rock at a velocity of 30 km/s suggests that the meteorite that formed Meteor Crater in Arizona had a mass between 30,000 and 194,000 tons, the range being due to uncertainty of the impact velocity. — D. B. V.

- 187-74. Innes, M. J. S. The use of gravity methods to study the underground structure and impact energy of meteorite craters: *Jour. Geophys. Research*, v. 66, no. 7, p. 2225-2239, 1961.

The mass deficiency and hence the amount of shattered rock under the Deep Bay, Brent, and Holleford meteorite craters in the Canadian shield have been computed from gravity data. The results show good agreement with the crater model computed by Rottenberg as combined with the depth/diameter ratios of Baldwin for meteorite impact craters. The zone of complete rupture is shown to extend to a depth of approximately one-third of the crater's diameter, and impact energy values, derived from the energy of crushing, are 6.5×10^{23} ergs, 2.1×10^{24} ergs, and 8.7×10^{25} ergs for Holleford, Brent, and Deep Bay, respectively. — D. B. V.

- 187-75. Beals, C. S. A probable meteorite crater of Precambrian age at Holleford, Ontario: *Dominion Observatory Ottawa Pubs.*, v. 24, no. 6, p. 117-142, 1960.

A circular feature 1.46 miles in diameter and 100 feet deep located at long 76°38' W. and lat 44°27' N. in southeastern Ontario has been investigated as a possible meteorite crater. Stereoscopic studies of aerial photographs in conjunction with geological and geophysical investigations (magnetic, seismic,

gravimetric) indicated the presence of a circular depression in Precambrian rock filled in and covered over by Paleozoic sediments. Three diamond drill holes were put down at distances of 1,400, 2,500, and 3,750 feet from the center to determine whether the depth of the base of the sediments and the subsurface structure are consistent with a meteoritic origin. The results show a depth and profile close to those predicted for a meteorite crater of the observed diameter. Below the sediments a thickness of several hundred feet of shattered and pulverized rock was found for which no adequate explanation has yet been found except that of meteorite impact and explosion (see *Geophys. Abs.* 182-295). — V. S. N.

- 187-76. Shoemaker, E[ugene] M., and Chao, E. C. T. New evidence for the impact origin of the Ries basin, Bavaria, Germany: *Jour. Geophys. Research*, v. 66, no. 10, p. 3371-3378, 1961.

The only direct evidence of magmatic activity at the Ries explosion crater in Bavaria is the presence of glass in scattered patches of a breccia called suevite. Some of the glass has long been recognized as sintered fragments of old crystalline rocks. It is found that glasses of various compositions coexist in a single suevite specimen, and that coesite and lechatelierite occur in the sintered rocks in the suevite. These same phenomena are present at Meteor Crater in Arizona, suggesting that the glassy components of suevite are of impact rather than volcanic origin. — D. B. V.

- 187-77. Baker, George. A perfectly developed hollow australite: *Am. Jour. Sci.*, v. 259, no. 10, p. 791-800, 1961.

A rare hollow australite found as a complete, non-weathered specimen near Horsham, western Victoria, was cut into two equal portions to reveal an internal cavity and described in 1898 by Walcott. A recent re-examination has shown that the australite resulted from ablation of a primary sphere of tektite glass containing a relatively large, eccentrically disposed, elliptical internal cavity. During the high speed unidirectional fall to the earth through the atmosphere, it maintained an aerodynamically stable orientation so that only the thicker surface directed forward was subjected to ablation from aerodynamic frictional heating. This process resulted in a loss of 43.6 percent of tektite glass from the original sphere without penetrating the internal cavity. — V. S. N.

- 187-78. Clarke, Roy S., and Carron, Maxwell K. Comparison of tektite specimens from Empire, Georgia, and Martha's Vineyard, Massachusetts: *Smithsonian Inst. Misc. Colln.*, v. 143, no. 4, 18 p., 1961.

Physical and chemical data and photographs are presented for specimens of tektites from Gay Head, Martha's Vineyard, Mass., and from Empire, Ga. A similarity between the two specimens is suggested by their close agreement in chemical composition, color, density, and magnetic properties, and by the similar lack of evidence in gross shapes or on the surfaces to suggest a history of aerodynamic shaping. From the data determined, it is not possible to report that these two specimens are unequivocally tektites. The chemical compositions separate the specimens from known tektite groups. All of the properties measured have counterparts in natural or artificial glasses. Further information on these tektites, particularly on their field occurrence, is necessary. — V. S. N.

- 187-79. Kopal, Zdeněk. The moon—our nearest celestial neighbour: New York, Academic Press, Inc., 131 p., 1960.

Our present store of knowledge concerning the physical properties and conditions prevailing on the surface of the moon are described for the layman in an easily followed account of telescopic examination and astronomical research. The text includes seven chapters as follows: prologue; facts and figures; strange world of the moon; the story of moonlight; lunar surface; changes on the moon; and destination moon. — V. S. N.

- 187-80. Kuiper, Gerard P. The moon, in The exploration of space: New York, MacMillan Company, p. 70-74, 1960.

This is virtually the same as the paper published previously in Jour. Geophys. Research, v. 64, no. 11, p. 1713-1719, 1959 (see Geophys. Abs. 179-25). — V. S. N.

- 187-81. Öpik, Ernst J. The origin of the moon: Space Sci., v. 10, no. 8, p. 2-7, 1961.

The changes in lunar orbit can be more or less reliably calculated for the past 4 billion years, but for the first 500 million years of the solar system's existence the uncertainty is great, involving the time, place, and mode of origin of both the moon and the earth. Assuming that the tidal friction between the earth and the moon is determined by the present rate of recession of the moon, it is possible to calculate backwards to find the lunar orbit at any time in the past. Gerstenkorn's theory that the moon came from a distant point on the earth's orbit—possibly opposite the earth—is discussed. Öpik believes, however, that the moon was formed in only 80 years from a ring or cloud of fragments circling the earth at a distance of 5 to 8 earth radii or farther. Tidal evolution started only at the time of the moon's formation. New criteria for deciding on the time and place of the birth of the moon is found in a study of the shapes of lunar craters (see Geophys. Abs. 186-92). — V. S. N.

- 187-82. Takeuchi, H[itoshi], Saito, M[asanori], and Kobayashi, N[aota]: Free oscillations of the moon: Jour. Geophys. Research, v. 66, no. 11, p. 3895-3897, 1961.

The free oscillations of a homogeneous self-gravitating elastic sphere are studied theoretically; numerical results for torsional and spheroidal oscillations are given in two tables that also show the free periods of a model moon having a density of 3.33 g per cm³ and shear wave velocity of 4.7 km/s. For this model, the effect of gravity on the periods of oscillation is shown to be negligible. The effect of curvature on phase velocity dispersion is estimated from the spheroidal oscillations. — D. B. V.

- 187-83. Bolt, Bruce A. Theoretical phase velocities for a lunar seismic experiment: Jour. Geophys. Research, v. 66, no. 10, p. 3513-3518, 1961.

Theoretical frequency spectra ${}_0S_{20}$ - ${}_0S_{150}$ of spheroidal eigenvibrations for three models of the moon are presented. The derived phase velocities for Rayleigh waves, with periods between 120 and 20 sec, are compared with phase velocities calculated using a plane-layer approximation. The comparison demonstrates that, for the moon, the latter approximation is inadequate for waves having periods exceeding 25 to 30 sec. The results (a) support a suggestion

that the operation of a single recorder of free lunar vibrations may provide discriminatory information on the interior of the moon and (b) provide data for the construction of such a recorder. — Author's abstract

- 187-84. Barabashov [Barabashev], N. P., Mikhailov, A. A., and Lipsky, Yu. N. Atlas obratnoy storony Luny [An atlas of the moon's far side]: Moskva, Akad. Nauk SSSR, 1960; English edition—Rodman, Richard B. (translator). An atlas of the moon's far side. The Lunik III reconnaissance: New York and London, Interscience Publishers, 147 p., 20 plates, 1961.

This atlas includes a map of the far side of the moon compiled from the Lunik III photographs, a catalog of physiographic features observed, and reproductions of 30 photographs. In the introductory section a brief discussion is given of the photographs and their transmission, and of the interpretive techniques used, particularly that of the successful photometric cross section method. — V. S. N.

- 187-85. Jeffreys, Harold. On the figure of the moon: Royal Astron. Soc. Monthly Notices, v. 122, no. 5, p. 421-432, 1961.

A rediscussion of the librations of the moon's axis is carried out literally to orders e^2 and i^2 of the main terms, and a solar effect not evaluated by Hayn is taken into account. It appears that solar effects nearly cancel out the corrections for e^2 and i^2 . The observational data are rediscussed, and it appears that $\beta = 0.006279 \pm 0.0000015$ if the discrepancies between the observational determinations can legitimately be treated as random, but if this is not true the uncertainty may well be multiplied by 4.

Recent discussions of the annual libration in longitude appear to give values of γ near to those given by the Yakovkin term. A method is proposed for dealing with the difficulty stated by Banachiewicz.

The data on the secular motions of the moon's node and perigee show no serious discrepancy with the results on its figure. — Author's summary

- 187-86. Hess, Wilmut N., and Nurdyke, M. D. Throwout calculations for explosion craters: Jour. Geophys. Research, v. 66, no. 10, p. 3405-3412, 1961.

Using information obtained from a 500-ton high-explosive blast, the apparent crater and lip shape and characteristics have been roughly calculated. By changing the gravity value and crater size, the appearance of lunar craters was calculated. It was found that a crater on the moon from a certain explosive yield should be about the same size as a crater on earth made by the same explosive yield. — D. B. V.

- 187-87. Cohen, A[lvin] J. Megashatter cone hypothesis of the origin of lunar volcanoes: Nature, v. 192, no. 4800, p. 346, 1961.

It is proposed that lunar volcanoes are not volcanoes, but extremely large shatter cones produced by the shock waves resulting from impact of an asteroid. These megacones are composed of smaller groups of shatter cones, like terrestrial shatter cones of the Kentland type (see Dietz, Geophys. Abs. 179-34, 182-68). It is proposed that the roots of a central uplift in a crater that was formed by a large impact explosion produced by a nickel-iron asteroid consist of a megamegacone composed in turn of many concentrically arranged megacones, all originally pointing upwards and inward toward the center of

impact. Most of these will have been almost instantly blown outward, leaving the central region filled with explosion breccia and (or) impact glass. Rebound after impact will lift this root structure a considerable distance, but it will always remain below the original lunar surface. — D. B. V.

- 187-88. Salisbury, John W. The origin of lunar domes: *Astrophys. Jour.*, v. 134, no. 1, p. 126-129, 1961.

This is the same paper as previously published in *Lunar and Planetary Explor. Colloquium Proc.*, v. 11, no. 2, p. 22-26, 1960 (see *Geophys. Abs.* 186-86). — D. B. V.

- 187-89. Space Science. Survival on the moon: *Space Sci.*, v. 10, no. 7, p. 2-4, 1961.

A condensation is given of the paper, "The application of geology to man's survival on the moon", presented by Jack Green before the meeting of the American Association for the Advancement of Science, in December 1960. Geology may provide knowledge of terrain features and their possibilities for concealment and protection—volcanic landforms would be particularly useful in this respect. Geologic mapping will lead to use of surface rock for insulation, building stone, and water content; to the use of minerals of a volcanic terrain to provide critical elements such as sulfur and ice; and may lead to sources of heat and power from local concentrations of radioactive rocks or from fumaroles at ray intersections. The geoscientist may prescribe the tools best suited for lunar exploration such as the density logger, neutron-neutron logger, and the neutron-gamma deuterium-tritium accelerator logger, as well as nuclear spectroscopy techniques. — V. S. N.

EARTH CURRENTS

- 187-90. Rikitake, Tsuneji. Sq and ocean: *Jour. Geophys. Research*, v. 66, no. 10, p. 3245-3254, 1961.

A theory of electromagnetic induction within a hemispherical conducting sheet over a nonconductor and underlain by a concentric sphere of uniform conductivity is described and applied to induction by Sq in a vast ocean. It is concluded that the electrical currents induced in the ocean are considerably smaller than those estimated for a single hemispherical sheet (about 2% maximum anomaly); therefore, electromagnetic coupling between the ocean and the nonconducting part of the earth's mantle cannot be neglected in a study of this kind. (See also *Geophys. Abs.* 184-133). — D. B. V.

- 187-91. Shuleykin, V. V. Eksperimental'naya proverka gipotezy o prirode magnitnogo skloneniya [Experimental test of the hypothesis concerning the nature of magnetic declination]: *Akad. Nauk SSSR Doklady*, v. 130, no. 5, p. 1015-1018, 1960.

The hypothesis that earth currents in the ocean cause at least part of magnetic declination was tested in the Atlantic Ocean between Africa and South America. The apparatus used consisted essentially of a ship's compass and a wrist watch with second sweep, together with a photographic recording device in a towed container. It was found that declination at 2,000 m depth was 5° less than that at the surface of the ocean. As this depth is negligible compared to the height of the ionosphere, the difference must all be due to earth currents in the ocean. Calculations show that here these currents account for about one-third of the total magnetic declination, the other two-thirds be-

ing due to ionospheric currents, which are also related to the distribution of continents and oceans. — D. B. V.

- 187-92. Shuleykin, V. V., and Sigachev, N. I. Novaya proverka gipotezy o prirode magnitnogo skloneniya [A new test of a hypothesis concerning the nature of magnetic declination]: Akad. Nauk SSSR Doklady, v. 140, no. 1, p. 107-110, 1961.

A new gyroscopic compass apparatus is described. Results obtained with it in the equatorial Atlantic Ocean support the hypothesis advanced by Shuleykin in 1958 (see Geophys. Abs. 174-10) that earth currents in the ocean are concerned in production of the latitudinal component of the direction of the geomagnetic field, or magnetic declination. Earth currents are responsible for about half of the latitudinal component. — D. B. V.

- 187-93. Kalmakov, M. V. Ob odnoy interesnoy osobennosti teoreticheskikh krivyykh magnetotelluricheskogo zondirovaniya [An interesting feature of theoretical curves of magnetotelluric sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 4, p. 583-587, 1961.

In calculating theoretical curves of magnetotelluric sounding (MTS) it is assumed that plane-polarized electromagnetic waves associated with oscillations of the earth's electromagnetic field impinge perpendicularly on a medium consisting of horizontal homogeneous layers. Surface measurements of the electric field E_x and the magnetic field H_y and of the phase angle ϕ between them at various periods of oscillation (T) furnish a basis for a layer analysis of the medium. The symmetry of MTS curves has been proved for specified relations between the parameters of geologic sections. This symmetry is characteristic of $|\rho_k / \rho_l|$ and ϕ curves. The symmetry reduces the work of calculation and the number of curves by one-half. The identical shapes of the symmetrical curves provide a graphic means of comparing MTS resolving power for different types of sections. — J. W. C.

- 187-94. Gugunava, G. E., and Chelidze, T. L. K voprosu primeneniya chastotnogo analiza pri geokartirovani dlinnoperiodnymi variatsiyami telluricheskikh tokov [On the problem of application of frequency analysis in subsurface mapping by means of long period variations of telluric currents]: Akad. Nauk Gruz. SSR Soobshch., v. 25, no. 6, p. 659-664, 1960.

An exploration method using long period variations in earth currents is discussed. The method of the tellurometer V is used in the treatment of the data obtained. This value is the ratio of the amplitude of variations of the potential gradient at the base point to that at a point that is moved along the profile. According to the theory, the depth h of penetration of a-c is determined by its wave length $\lambda = 10^3 (10\rho T)^{\frac{1}{2}}$, where ρ is resistance in ohms, and T is period in sec. In practice, however, the penetration depth was found to be different; it can be calculated by a modified formula. — A. J. S.

- Kántás, Karl. Geophysical interpretation problems in the Vienna Basin. See Geophys. Abs. 187-328.

Shuleykin, V. V. Some features of the secular variation of the magnetic field over the oceans. See Geophys. Abs. 187-410.

- Rikitake, T[suneji]. The effect of the ocean on rapid geomagnetic changes. See Geophys. Abs. 187-424.

- 187-95. Kataja, Airi. The 1960 Kuusamo-Salla earthquake, II. Macro-seismic data: *Geophysica* [Helsinki], v. 7, no. 3, p. 179-189, 1961.

The macroseismic data from two earthquakes that occurred in Finland on February 2 and February 20, 1960 are tabulated. The strongest intensities felt indicate that the epicenters were at lat 66.92° N., long 31.02° E. and lat 66.59° N., long 28.76° E., respectively. The macroseismic distribution in Finland was about 18,000 and 14,000 km², respectively. The highest intensity for both was 5, but it is possible that the earlier event was of intensity 6 at the epicenter. The nature of the ground exerted some influence on the felt area because intensities diminished more quickly in some directions than in others. — V. S. N.

- 187-96. Central Water and Power Research Station Poona. Earth tremors at Mangalam damsite, January-March 1960: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 221-223, 1961.

Results of a study of the numerous mild tremors in the vicinity of Mangalam damsite, Kerala State, India, of January-March 1960, and of the field examination of any possible damage to the dam structure are reported. It is concluded from the tectonics and seismicity of this and neighboring areas that no severe seismic activity is anticipated in this or other parts of the west coast of India south of Bombay. Acceleration from earthquakes, even at the epicenters, will be very small, and in general no seismic factor need be incorporated in the design of dams in this area. — V. S. N.

- 187-97. Tskhakaya, A. D., and Sikharulidze, D. I. Zemletryaseniye v verkhney megrel'ii 25 XII 55 [Earthquake in the upper Megrel, December 25, 1955]: *Akad. Nauk Gruzin, SSR Soobshch.*, v. 20, no. 1, p. 27-34, 1958.

An earthquake of 6-7 points intensity took place in the Megrel Range, a south spur of the central Caucasus, on December 25, 1955. This was part of a renewed seismic activity in the western and central Caucasus that began in 1955 after a period of calm since 1902. An isoseismic map shows the epicenter and the intensity zones. The epicenter was located on the Megrel fault. — J. W. C.

- 187-98. Bune, V. I. Posleduyushchiye tolchki Nurekskogo zemletryaseniya 9/22-1956 i otsenka seysmicheskoy aktivnosti Bol'shogo Stalinabadskogo rayona [Aftershocks of the Nurek earthquake of September 22, 1956, and estimation of the seismic activity of the Great Stalinabad region]: *Akad. Nauk Tadzhik SSR Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy*, v. 6, p. 109-140, 1960.

The seismicity of the Stalinabad region (38.0°-39.0 N. and 68.0°-69.5° E.) is examined in the light of the number of aftershocks that followed the Nurek earthquake of September 22, 1956. The interference of the aftershocks with determination of the seismic parameters of the region was investigated, and the disturbance of the "normal" seismic regime by the aftershocks was estimated from the 1955-58 records of highly sensitive seismic stations and from records of standard stations for 1929-58. — A. J. S.

- 187-99. Kinyapina, T. A. Nurekskoye zemletryaseniye 28 yanvarya 1957 [The Nurek earthquake of January 28, 1957]: *Akad. Nauk Tadzhik*

SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 183-196, 1960.

The Nurek earthquake of January 28, 1957 at 21^h01^m G. m. t. in the central part of the Tadzhik S. S. R. between the Ilyak and Vakhsh Rivers is described. Its focal depth was determined to be 5 km, and the intensity estimated at 6-7 points. The epicentral zone lies on the northeastern boundary fault of the Kara Tau anticline. This earthquake is considered to be possibly a strong aftershock of the Nurek earthquake of September 22, 1956 (see Geophys. Abs. 187-98). — A. J. S.

- 187-100. Vasil'yeva, L. B. Andzhirskoye zemletryaseniye 1953 [The Andzhir earthquake of 1953]: Akad. Nauk Tadzhik SSR, Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 6, p. 171-182, 1960.

The Andzhir earthquake of 7-8 points intensity occurred on July 7, 1953 at 7h21^m local time and caused destruction in several villages to the south of Stalinabad. The geology of the region is described, and the origin of the earthquake is discussed. — A. J. S.

- 187-101. Morgan, W. J., Stoner, J. O., and Dicke, R. H. Periodicity of earthquakes and the invariance of the gravitational constant: Jour. Geophys. Research, v. 66, no. 11, p. 3831-3843, 1961.

Times of occurrence for a total of 1,933 earthquakes are analyzed for periodicities. The results show no definite evidence for effects due to earth tides. Small indications of a solar-date periodicity are assumed to be thermal in origin. A strong statistically significant annual period is found, and the phase is substantially the same for northern and southern earthquakes. This periodicity is not wholly accounted for by temperature effects, wind-induced stresses, and observer bias. The occurrence of this periodicity would be understandable if the gravitational constant were to vary as the earth-sun distance changes or as the earth's velocity relative to a preferred coordinate frame changes; however, the observed periodicity cannot be interpreted as conclusive support for such a hypothesis. — Author's abstract

- 187-102. Puchkov, S. V. Nekotoryye voprosy rascheta elementov seysmicheskikh kolebaniy dlya mikrorayonirovaniya [Certain problems of calculation of the elements of seismic oscillations for microregionalization]: Akad. Nauk Tadzhik SSR Inst. Seysmologii Trudy, v. 113, p. 69-83, 1959.

The engineering basis for seismic microregionalization is discussed, and a mathematical analysis is given for ways of expressing seismic oscillations during their passage through an acoustically rigid medium. The problems arising in determination of the maximum force of an earthquake on the surface of the bed rock, resonant oscillations of a layer, displacements on the surface of a thin layer by repeatedly reflected seismic waves, and the affect of the duration of seismic oscillations for various grounds are investigated and discussed. — A. J. S.

- 187-103. Gutenberg, B[eno]. Earthquakes in North America, in Smithsonian treasury of science, v. 2: New York, Simon and Schuster, Inc., p. 379-397, 1960.

This paper was originally published in the Smithsonian Report for 1950 (also in Science, see Geophys. Abs. 142-12190) and is reprinted here with minor revisions made in 1959. — V. S. N.

- 187-104. Kárník, Vít. Seismicity of Europe. Progress report II: Internat. Union Geodesy and Geophysics Mon., no. 9, 31 p., 1961.

At the meeting of the European Seismological Commission in Helsinki in 1960 it was reported that the first draft of an earthquake catalog and several seismicity maps for Europe, covering the period 1901-55, have been prepared. A list of sources is given by country. The contents of individual columns in the catalog and problems connected with them are discussed. For orientation purposes and for classification of earthquakes, values of magnitude (M) were calculated for various maximum intensities (I_0) on the Mercalli-Sieberg scale by means of the formula $M=0.67 I_0+1.7 \log h-1.4$ (h =focal depth). Seven classes of earthquakes were used. In view of the limited accuracy of the information and for practical treatment of a large number of observations, it is proposed that in future compilations the number of classes be reduced to four: $I_0=6$ ($M=4-4 \frac{3}{4}$), $7-8$ ($M=5-6 \frac{1}{4}$), $9-10$ ($M=6 \frac{1}{2}-7 \frac{1}{2}$), and $11-12$ ($M \approx 7 \frac{3}{4}$).

Five maps are given, showing the distribution of epicenters in each of the 7 classes for shallow ($h < 60$ km) and deep-focus earthquakes in Europe and the Mediterranean area during the period 1901-55. — D. B. V.

- 187-105. Savarenskiy, Ye. F., and Dzhibladze, E. A. Ob energii zemletriyaseny Bol'shogo Kavkaza [On the energy of earthquakes of the Great Caucasus]: Akad. Nauk Gruzin. SSR Soobshch., v. 18, no. 1, p. 25-29, 1957.

The earthquakes of the Great Caucasus are classified according to their energy and to features of their epicentral areas (see also Geophys. Abs. 166-67, 176-34). — A. J. S.

- 187-106. Gayskiy, V. N., Katok, A. P., and Bil'man, B. M. O seysmichnosti Tadzhikestana v 1957 [On the seismicity of Tadjikistan in 1957]: Akad. Nauk Tadjik SSR, Inst. Seysmostoykogo Stroitel'stva i Seismologii Trudy, v. 6, p. 89-108, 1960.

Seismic activity in the Tadjik S.S.R. during 1957 is analyzed on a basis of 208 earthquakes recorded by the regional network of seismic stations of central Asia. — A. J. S.

- 187-107. Bune, V. I., and Reyman, V. M. K seysmotektonicheskoy kharakteristike tsentral'noy chasti Tadjhikskoy depressii [On the seismotectonic characteristic of the central part of the Tadjik depression]: Akad. Nauk Tadjik SSR Inst. Seysmostoykogo Stroitel'stva i Seysmologii Trudy, v. 7, p. 3-26, 1960.

A comparison of data on the main faults and on the location of epicenters of earthquakes is given on the basis of seismic and geologic findings in the Vakhsh River area in 1955-58. The epicentral zone in the area is related to Alpine faults. The planes of the faults dip steeply; they are observed seismically to a depth of 30 km. Migrations of epicenters along the faults are observed. The maximum (9 points M. M.) of earthquake intensity is correlated with the Vakhsh regional fault, and seismically dangerous zones with fault junctions. — A. J. S.

- 187-108. Riznichenko, J. [Yu.] V., and Nersesov, I. L. A detailed study of the seismic regime in the Garm epicentral region: *Annali Geofisica*, v. 14, no. 2, p. 173-186, 1961.

A five-year detailed instrumental study of earthquakes in the Garm-Stalinabad seismic region of the Tadzhik S.S.R. has resulted in a method of quantitative determination of the seismic activity (A) of a region. The value A represents the frequency of occurrence of earthquakes in a given area and in a given energy range, where the number of earthquakes is large enough to afford reliable statistical conclusions. Quantitative determination of seismicity cannot be based only on the strongest earthquakes but must also take A into account.

A special study of temporal changes in A after strong earthquakes suggests that in some cases A varies in inverse proportion to the time elapsed since a strong shock. — D. B. V.

- 187-109. Rozova, Ye. A. Voprosy stroitel'stva v seysmicheskikh rayonakh [Problems of construction in seismic regions]: *Akad. Nauk SSSR Vestnik*, v. 31, no. 9, p. 73-75, 1961.

The growing industry in the Kirgiz S.S.R. has created the necessity for seismicity maps for use in planning industrial construction. This region is classed almost entirely as 8 or 9 intensity zones. Microregionalization studies are now being made to determine the best areas for location of population centers. — J. W. C.

- 187-110. Fedotov, S. A., Averjanova [Aver'yanova], V. N., Bagdasarova, A. M., Kuzin, A. P. [Kuzin, I. P.], and Tarkanov [Tarakanov], R. Z. Some results of the detailed study of the south Kurile Islands seismicity: *Annali Geofisica*, v. 14, no. 2, p. 119-136, 1961.

This is essentially the same paper as previously published in *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 5, p. 633-642, 1961 (see *Geophys. Abs.* 186-149). — D. B. V.

- 187-111. Hatherton, T. A note on the seismicity of the Ross Sea region: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 252-253, 1961.

Although the aseismicity of Antarctica has been confirmed by International Geophysical Year observations, small local disturbances, up to magnitude 3, are almost a daily feature of seismograms at Scott Base. S-P intervals of these shocks range from 3 to 38 sec but half of the shocks recorded have S-P differences of 4-6 sec, values appropriate to the distance of Mount Erebus. An unusual low-velocity phase (V about 0.6 km/s) is present on many seismograms. — Author's summary

- 186-112. Ragimov, Sh. S. O napravlenii storon treugol'nika stantsiy pri opredelenii azimuta seysmicheskikh voln metodom troynnykh stantsiy [On the orientation of the sides of the triangle of stations in determination of the seismic waves azimuth by the three stations method]: *Akad. Nauk Azerbaydzhan. SSR Doklady*, v. 16, no. 6, p. 547-548, 1960.

A suggestion is made to orient the sides of the three-station triangle arrangement, used in determination of propagation direction of seismic waves, in such a way that the equation $\tan A_z = \tau_{13} / \tau_{12}$ (in which A_z is the azimuth angle;

$\tau_{12}=T_1-T_2$; $\tau_{13}=T_1-T_3$; and T_1 , T_2 , and T_3 are the arrival times of the same wave at stations 1, 2, and 3, respectively) is satisfied when the angle α (azimuth of the side 1, 2) equals zero. Such an arrangement shortens the computation work considerably. — A. J. S.

- 187-113. Ayzov, I. V. Zavisimosti mezhdu ball'nost'yu, intensivnostyu i glubinoy ochaga dlya kavkazskikh zemletryaseniy [Correlation between intensity, magnitude, and focal depth for Caucasus earthquakes]: Akad. Nauk Gruzin. SSR Soobshch., v. 26, no. 2, p. 149-152, 1961.

The correlation between J , M , and h is given in the form $J_0 = P + QM - T \log h$, where J_0 is intensity at the epicenter, M is the magnitude, and h is the depth of the earthquake, P , Q , and T being constants. Shebalin's formula $J_0 = (3.0 \pm 0.3) + (1.52 \pm 0.1)M - (3.2 \pm 0.3) \log h$ calculated for the U. S. S. R. was modified for earthquakes in the Caucasus as follows: $J_0 = (3.22 \pm 0.5) + (1.08 \pm 0.25)M - (1.23 \pm 0.61) \log h$. Comparative values of intensities of 23 earthquakes calculated with this formula are given. — A. J. S.

- 187-114. Balakina, L. M., Savarensky, E. F. [Savarenskiy, Ye. F.], and Vvedenskaya, A. V. On determination of earthquake mechanism, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 211-238, 1961.

Existing methods for the representation of earthquake focuses by equivalent sources are discussed. The review demonstrates that two different points of view exist on the nature of the mechanism at the focus: One group (Byerly, Hodgson, Keylis-Borok) consider the system equivalent to the shear in the fault plane as a double concentrated force with moment; the other group (Honda, Vvedenskaya) consider it to be a distributed system of forces that can be represented as two equal as to value, perpendicular and oppositely directed double forces without moment. The position of the nodal planes relative to each other for the displacement field in longitudinal waves is the same for both mentioned sources; therefore, reliable observations of transverse waves must be made in the future to judge which of them corresponds to the real focus. It is noted that investigations using two different representations of the real focus as equivalent sources lead to different conclusions as to the nature of the forces acting at the focus and to different conclusions as to the relations of the mechanism of earthquakes and the character of tectonic processes. It is impossible, moreover, to describe the process at an earthquake focus within the limits of the theory of elasticity that is used by all authors. A bibliography of 58 items is included. — V. S. N.

- 187-115. Ritsema, A. R. Some 1951 earthquake mechanisms based on P and PKP data: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 254-258, 1961.

Fault plane solutions are presented for 24 earthquakes that occurred in 1951. Results are summarized in a table that gives for each earthquake the date, time, epicenter, depth, azimuth and plunge of the A-, B-, and C-axes, type of fault motion, and number of consistent and inconsistent data. Only one of the two possible solutions is given; the other may be obtained by interchanging the A- and C-axes and the dextral and sinistral parts of the fault motion. — D. B. V.

- 187-116. Ben-Menahem, Ari. Radiation of seismic surface waves from finite moving sources: Seismol. Soc. America Bull., v. 51, no. 3, p. 401-435, 1961.

A theory is proposed for the propagation of seismic surface waves from finite moving sources. Basic solutions obtained for surface displacements from directional sources are integrated to obtain the effect of a moving fault with arbitrary dip angle. Displacements are evaluated for Rayleigh and Love waves at long ranges. It is shown that the source dimensions and speed of rupture play an important role in the wave pattern and cannot be ignored when source dimensions are of the order of the radiation's dominant wavelength. It is demonstrated how this theory may lead to a derivation of the velocity of rupture and length of faulting from the records of a single station. — D. B. V.

- 187-117. Press, Frank, Ben-Menahem, Ari, and Toksöz, M. Nafi. Experimental determination of earthquake fault length and rupture velocity: Jour. Geophys. Research, v. 66, no. 10, p. 3471-3485, 1961.

Three methods of determining the fault parameters of length and rupture velocity are examined with ultrasonic models. The theory behind the methods is shown to have a valid though approximate basis. Oversimplified assumptions and imperfect experimental data restrict initial results to only rough indications of fault parameters. When applied to the great Chilean earthquake of May 1960, a fault length of the order of 1,000 km and a rupture velocity near the speed of shear waves in crustal rock are found. — Authors' abstract

- 187-118. Vvedenskaya, A. V. Osobennosti napryazhennogo sostoyaniya v ochagakh pribaykal'skikh zemletryaseniy [Features of the strain state at the focuses of earthquakes in the Baikal region]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 666-669, 1961.

Study of stresses at the focus of the earthquake of August 29, 1959 in the middle Baikal region ($\lambda=107.1^\circ\text{E}$, $\phi=52.6^\circ\text{N}$, $M=6\frac{1}{2}-6\frac{3}{4}$) shows that the principal stress axes correspond to the predominant direction of these axes in the northeastern and southwestern Baikal region. — A. J. S.

- 187-119. Kasahara, Keichi. An attempt to detect azimuth effect on spectral structures of seismic waves (The Alaska earthquake of April 7, 1958): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 207-218, 1960.

A spectral analysis of seismic waves from the Alaskan earthquake of April 7, 1958, was worked out in order to determine whether the "point" or "spherical" origin models explain earthquake mechanism satisfactorily. If they are valid, waves of the same spectral structure should be observed at all azimuths. Records obtained by Press-Ewing seismographs at Tsukuba, Japan, Uppsala, Sweden, Resolute Bay, Canada, Honolulu, Hawaii, and at Palisades, Waynesburg, and Pasadena in continental United States were used; all but Resolute Bay are almost equally distant ($\Delta=40^\circ-45^\circ$) from the epicenter.

No special azimuth effect was noted in the spectrums of P-waves, but there were noticeable differences in the S-wave spectrum types observed at three groups of stations. These differences could be due to the mechanism of wave radiation rather than to distortion of spectrums by conditions of wave propagation, but until more data are available it is premature to conclude that a true azimuth effect is present. — D. B. V.

- 187-120. Kuo, Tseng-Chien. Notes on the fault-plane determination by means of initial motions of earthquakes (continued) [in Chinese with English abstract]: Acta Geophys. Sinica, v. 7, no. 2, p. 91-97, 1958.

Formulas are given for determination of the nodal line of a fault plane by means of the nodal line of an auxiliary plane and for determination of the epicentral distances Δ_s and Δ'_s of the intersections of the displacement of S-waves at the focus with the earth's surface. From the results of the latter formula a method is proposed for the determination of the direction of motion by means of S-waves recorded at two stations. — V. S. N.

Gougenheim M. André. Confirmation, by observation, of the negligible role of the earth tide in the production of earthquakes. See *Geophys. Abs.* 187-146.

187-121. Chinnery, M. A. The deformation of the ground around surface faults: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 355-372, 1961.

A rectangular dislocation surface (one across which there is a discontinuity in the displacement vector) is used as a model of a vertical transcurrent fault, and the displacement field throughout a semi-infinite elastic medium due to such a dislocation is derived in analytical form. Displacements of the surface of the medium are calculated in some detail. Methods are then discussed for the determination of depth of a surface fault from measurements of ground deformation, and these are applied to faults associated with the Tango and North Idu earthquakes and to the San Andreas faults. Good agreement between observed deformation and theory suggests that the dislocation theory provides a good description of the effects of fracture in the earth's crust. — D. B. V.

187-122. Tazieff, H[aroun]. Interprétation des glissements de terrain accompagnant le grand séisme du Chili [Interpretation of the landslides accompanying the great Chilean earthquake]: *Soc. Belge Géologie, Paléontologie et Hydrologie Bull.*, v. 69, no. 3, p. 374-384, 1960 (1961)

The Chilean earthquake of May 22, 1960 was felt over an area of 160,000 km² (see *Geophys. Abs.* 184-134, -135; 185-131). In addition to the destruction due directly to the shocks, destruction by the resulting tsunami, and subsidence of a coastal strip some hundreds of kilometers long and tens of kilometers wide, there were numerous landslides in the vicinity of Lakes Rinihue, Panguipulli, Calafquén, and Neltume in the spurs of the Andes. Millions of cubic meters of material were moved; mainly involved were inclined beds of dry, more or less coherent Pliocene or Pleistocene tuffs. These landslides differed considerably from ordinary landslips and from avalanches of mud (lahars), ice, or snow in that the horizontal displacement was 5 to 10 times greater than the vertical.

It is suggested that the horizontal components of S- and L-waves were sufficiently strong to provoke the landslides, and that the long duration (200-210 sec) of the shocks produced a shaking table effect that brought about the unusually great horizontal movement. — D. B. V.

187-123. Nazarov, A. G. Zadachi issledovatel'skoy raboty v oblasti seysmostoykogo stroitel'stva v Tadzhikskoy SSR [The tasks of research in the field of seismic resistant construction in the Tadzhik SSR]: *Akad. Nauk Tadzhik SSR Inst. Seysmologii Trudy*, v. 113, p. 25-36, 1959.

This is a brief statement of engineering problems in improving seismic resistance of buildings and other engineering constructions in the Tadzhik

S. S. R. Addition of accelerographs, deformometers, analyzers, and other seismic instruments to the equipment of the seismic stations is recommended. — A. J. S.

- 187-124. Nishimura, Genrokuro, and Suzuki, Masazi. Aseismic properties of a wooden house (pt. 3): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 329-343, 1960.

The free vibration of a pendulum of simple mass system, in which the restoring force varies at each amplitude, is considered; the relationships between amplitude, period, and damping factor are derived theoretically; and numerical calculations are made using the experimental data obtained for the free vibration of wooden houses when seismic wave amplitude is great (see also Geophys. Abs. 175-43). — D. B. V.

- 187-125. Kon'no, Enzo, and others. Geological observations of the Sanriku coastal region damaged by the tsunami due to the Chile earthquake in 1960: Tohoku Univ. Inst. Geology and Paleontology Contr., no. 52, 40 p., 1961.

The erosional and depositional effects of the tsunami of May 1960 on the Sanriku coastal area of Honshu Island, Japan, are discussed in detail. This tsunami, caused by the Chilean earthquake of May 1960 is in sharp contrast to those of 1896 and 1933 in this area. The waves were of much longer wavelength and period (40-45 min at Onagawa, Miyagi Prefecture). — V. S. N.

- 187-126. MacDonald, Gordon J. F. The earth's free oscillations: Science, v. 134, no. 3491, p. 1663-1668, 1961.

The use of free, low-frequency normal modes of vibration of the earth (observed for the first time in the Chilean earthquake of May 1960) supplements observations of arrival times of high-frequency earthquake waves that heretofore provided almost all information on the nature of the earth's interior. The theory of the earth's free oscillations, the attempts to detect them, and the results of the first observations are reviewed (see also Geophys. Abs. 184-183 through 184-190). — D. B. V.

- 187-127. Buchheim, W[olfgang], and Smith, S. W. The earth's free oscillations observed on earthtide instruments at Tiefenort, East Germany: Jour. Geophys. Research, v. 66, no. 10, p. 3608-3610, 1961.

The Chilean earthquake of May 1960 wrote unusual long-period records on the horizontal pendulum seismographs designed for recording earth tides at Tiefenort, East Germany. In spite of difficulties of frequency resolution, the cross spectrum of the E-W component and of a comparable E-W pendulum at Pasadena leaves no doubt that the spectral peaks observed at Tiefenort represent coherent vibrations of the whole earth. The lowest mode recorded with certainty is ${}_0S_4$ with a period of 25.8 min, and the highest mode is ${}_0S_{16}$ with a period of 6.78 min. Observed periods and tentative mode identifications are tabulated. Although less precise than previously published values (see Geophys. Abs. 184-185, -186), these are at present the only available observations of the free oscillations in the eastern hemisphere. — D. B. V.

- 187-128. Takeuchi, Hitoshi, and Saito, Masanori. Free oscillations of the earth: Japan Acad. Proc., v. 37, no. 1, p. 33-36, 1961.

The problem of the earth's free spheroidal oscillations is studied by solving three simultaneous differential equations among $U(r)$, $V(r)$, and $P(r)$. It is assumed that the density ρ and elastic constants λ and μ of the earth are given functions of distance r from its center. The (r, θ, ϕ) components of displacement u and an additional potential P due to the earth's deformation are denoted respectively by:

$$u_r = U(r)S_n(\theta, \phi), u_\theta = V(r)\frac{\delta S_n(\theta, \phi)}{\delta \theta}, u_\phi = \frac{V(r)}{\sin \theta} \frac{\delta S_n(\theta, \phi)}{\delta \phi}, P = P(r)S_n(\theta, \phi)$$

where a common time factor $e^{i\sigma t}$ is omitted and $S_n(\theta, \phi)$ is a spherical harmonic of order n . These equations will determine the period $T=2\pi/\sigma$ of its free oscillation as a function of the azimuthal wave number n . Calculations are given for the Jeffreys-Bullen earth model up to $n=5, 6, 8, 10, 16, 24, 38$, and 96 , and for the Gutenberg model up to $n=16, 24, 38$, and 96 . Calculated periods agree well with observed values and thus, the models used are representative of the internal constitution of the earth. — V. S. N.

- 187-129. Cameron, J. B. Earthquakes in the northern California coastal region (pt. 2): *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 337-354, 1961.

The P_F phase (False S) is shown to be a longitudinal wave having a velocity of 5.1 kmps, which arrives at the observing station with an angle of emergence less than that observed for P_n . The epicenter locations of earthquakes in northern California show that this phase arises only from shocks originating on continental structure. The P_n - P relationship and the intensity indicate that exceptionally shallow focuses generate the P_F phase. It is concluded that the very thick Franciscan formation in northern California carries considerable energy from these shallow earthquakes, and this energy is identified as the P_F phase. (See also *Geophys. Abs.* 186-135.) — D. B. V.

- 187-130. Green, R. Appearance of the T-phase: *Nature*, v. 191, no. 4792, p. 997-998, 1961.

Phases similar to those reported by Robson and Barr in Dominica (see *Geophys. Abs.* 183-110) have been noted on Tasmanian records. Some have been identified as due to natural earthquakes on the New Zealand side of the Tasman Sea, and some as due to depth charges set off by naval ships. It is suggested that the energy travels as a compressional wave with a velocity of 1.47 kmps down the "Sofar channel," a low-velocity waveguide at 1,500 m depth in the ocean. This channel-wave phase (T-phase) is converted to a P-phase, and presumably an S-phase, at the Continental Shelf; as recorded by a seismic station the P-phase appears to originate from a disturbance on the shelf. Analysis of records of two earthquakes in the Milford Sound region of New Zealand shows that the channel wave arrives 15-20 min after the P-phase, and that the wave front formed at the Continental Shelf travels over the continent as a shallow P-wave.

If Robson and Barr could find evidence of small shocks somewhere in the Caribbean Sea preceding their disturbances, the problem would be unambiguously solved. Suggestions are made as to why such a phase is picked up only on the sediments of the Roseau River and not over the whole island of Dominica. — D. B. V.

- 187-131. Porkka, M. T. Surface wave dispersion for some Eurasian paths, II. Love waves: *Geophysica [Helsinki]*, v. 7, no. 3, p. 151-160, 1961.

The results of an investigation of Love waves from 19 earthquakes are discussed. The dispersion data for seismic wave paths from Japan, Formosa, and the Altay to Helsinki are consistent with one another, but paths that cross the great Asian Tertiary massif show lower group velocities for corresponding periods. The latter effect is interpreted as a result of crustal thickening of about 20 km in this region of young mountain ranges as compared with the average crustal thickness of this continent. — V. S. N.

Hales, A. L. A weak layer in the mantle? See *Geophys. Abs.* 187-371.

Kovach, Robert L., and Press, Frank. Rayleigh wave dispersion and crustal structure in the eastern Pacific and Indian Oceans. See *Geophys. Abs.* 187-367.

Aki, Keiiti. Crustal structure in Japan from the phase velocity of Rayleigh waves. Part 1. Use of the network of seismological station operated by the Japan Meteorological Agency. See *Geophys. Abs.* 187-363.

Santo, Tetsuo A[kima]. Rayleigh wave dispersions across the oceanic basin around Japan (Pt. 3)—On the crust of the south-western Pacific Ocean. See *Geophys. Abs.* 187-366.

Kovach, Robert L., and Press, Frank. Surface wave dispersion and crustal structure in Antarctica and the surrounding oceans. See *Geophys. Abs.* 187-368.

187-132. Ewing, John [I.], and Ewing, Maurice. A telemetering ocean-bottom seismograph: *Jour. Geophys. Research*, v. 66, no. 11, p. 3863-3878, 1961.

Tests on three occasions show that the system of placing a receiving installation on the sea floor and acoustically telemetering the information to a surface ship is feasible. Information was also gained for more advanced instruments and methods of transmittal that will ultimately make up a worldwide system. Such a system could settle the question of the origin and propagation of microseisms; provide detailed information about the sedimentary layer, the crust, and the mantle; and greatly increase the radius over which a single station can monitor small earthquakes or explosions.

Body waves from an earthquake were recorded, indicating that a good signal-to-noise ratio was achieved. Useful data were obtained on background noise in the short-period range. Long refraction profiles have given additional measurements of crustal and mantle P- and S-waves. Variation in the amount of energy propagated along various refraction paths indicates appreciable local and regional differences in the crust-mantle interface. — D. B. V.

187-133. Teupser, C[hristian], and Ullmann, W. Ein neuer Horizontalseismograph mit galvanometrischer Registrierung [A new horizontal seismograph with galvanometer recording (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 6, p. 272-279, 1959.

A horizontal-component electromagnetic seismograph that accurately records amplitudes of ground motion in a period range of 0.1-15 sec is described. The apparatus has a magnification of 1,000. The constants of the pendulum and of the galvanometer are given. The pendulum period is 20 sec, and the free period of the heavily damped galvanometer is 1 sec. — D. B. V.

- 187-134. Hiersemann, Lothar. Aufzeichnung langperiodischer Bodendeformationen mit einem Strainseismometer [Registration of long-period ground deformations with a strain seismometer (with English summary)]: *Zeitschr. Geophysik*, v. 27, no. 1, p. 18-34, 1961.

A strain seismometer constructed at Freiberg, German, is described, with emphasis on the differences between this and pendulum instruments, and results of preliminary tests are reported. The records are somewhat affected by meteorological conditions, including thermoelastic deformation, atmospheric pressure variations, wind, and rainfall. — D. B. V.

- 187-135. Lossovskiy, Ye. K. Pro vrakhuvannya chutlyvosti pryymayuchikh kanaliv pri pobudovi amplitudnykh grafikiv seysmichnykh khvil' [Allowing for sensitivity of receiver channels when plotting amplitude graphs of seismic waves]: *Akad. Nauk Ukrayin. RSR DoprivdI*, no. 7, p. 904-907, 1961.

A graphical method is presented for introducing into amplitude graphs of observed seismic waves corrections allowing for unequal sensitivity of the receiving channels. Such a method can be applied when the amplitude graph of the relative sensitivity of the recording amplifiers is available. — A. J. S.

- 187-136. Matumoto, Hideteru. A transistor amplifier for seismographs (in Japanese with English summary): *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 2, p. 345-354, 1960.

A new portable seismograph has been constructed, making use of a transistor amplifier (see *Geophys. Abs.* 186-217). The amplifier is described, with schematic diagrams, photographs, and graphs of frequency characteristics. The use of transistors rather than vacuum tubes not only increases the sensitivity but also extends the frequency range downward. — D. B. V.

- 187-137. Boletín Sismológico del Servicio Geológico Nacional de El Salvador. Informe sobre la instalación de una nueva estación sismológica en el occidente de la República de El Salvador [Report on the installation of a new seismological station in the western part of the Republic of El Salvador]: *El Salvador Servicio Geol. Nac. Bol. Sismol.*, v. 7, p. 2, 1961.

The completion of a new seismic station in Ahuachapan, El Salvador, equipped with two seismographs (N-S and E-W components) constructed by the Servicio Geológico Nacional, is reported and the constants of the instruments are given. The station is intended mainly to record local earthquakes. — D. B. V.

- 187-138. Hodgson, J[ohn] H., and Langill, F. E. Bibliography of seismology—July-December, 1958: *Dominion Observatory Ottawa Pubs.*, v. 22, no. 4, p. 87-133, 1961.

The regular semiannual issue of the bibliography of seismology is presented. A continuation of the subject index is included. (See also *Geophys. Abs.* 177-33, -34, 180-32.) — V. S. N.

EARTH TIDES AND RELATED PHENOMENA

- 187-139. Vicente, R. O. The theory of nutation and the internal constitution of the earth, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 251-280, 1961.

The classical theory of nutation is explained giving numerical results obtained theoretically and a kinematic description of the motion. The values of nutations obtained from observations are examined and compared with theoretical values, and disagreements between the two are observed. The relationship of earth tides and the internal constitution of the earth are discussed. Modern researches on the theory of nutation that consider existence of a shell and a core and different properties for the two main regions of the interior are reviewed, and the actual theory of nutation proposed by Jeffreys and Vicente is summarized. — V. S. N.

- 187-140. Weissberg [Vaisberg], O. L. O vozmozhnom zamedlenii vrashcheniya Zemli [On a possible retardation of the earth's rotation]: *Astron. Zhur.*, v. 38, no. 3, p. 545-548, 1961.

The mechanisms that could lead to the retardation of rotation of the earth during the solar flares of February 23, 1956 and July 15, 1959 are discussed. As established by Danjon, the length of the day was increased by 1.1×10^{-10} part during the first disturbance and by 0.85×10^{-8} part during the second. A first hypothesis, assuming an increase in density of the upper atmosphere due to an influx of corpuscular radiation from the sun and subsequent increase of the earth's moment of inertia, was found to be insufficient to explain the retardation observed. A second hypothesis explains the effect by emission of magnetohydrodynamic waves due to the rotation of the earth's magnetic dipole whose axis is inclined by 11.5° to the axis of rotation of the earth in interplanetary plasma. Maeda (1957) analyzed the problem of distortion of the earth's dipole magnetic field due to the earth's axial rotation in interplanetary plasma and determined the power of the emitted magnetohydrodynamic waves to be 10^{18} ergs per sec. On this basis, and assuming an exponential relationship between the ratio ω/a (angular momentum of the earth to the speed of magnetohydrodynamic waves) and the power, W , of the waves, an energy influx of the order of 10^{26} ergs coming to the earth during the solar flare is obtained, thus giving values of energy comparable to that needed to change the earth's moment of inertia by the observed retardation. — A. J. S.

- 187-141. Jones, Harold Spencer. Variations of the earth's rotation, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 186-210, 1961.

The three types of departure from uniformity in the rotation of the earth are discussed, the methods to detect and measure them are reviewed, and the causes of the variations are summarized. — V. S. N.

- 187-142. Verbaandert, J., and Melchior, P[aul] [J.]. La station des pendules horizontaux de Sclaigneaux (Province de Namur) [The horizontal pendulum station at Sclaigneaux (Namur Province)]: *Acad. Royale Belgique Bull. Cl. Sci.*, ser. 5, v. 45, no. 11, p. 1084-1086, 1959; v. 46, no. 2, p. 75-78, 1960.

The first paper describes the pendulum apparatus installed in a mine in the dolomite at Sclaigneaux, Belgium, to measure earth tides. The pendulum for measuring the N-S component has been in operation since November 1959,

and that for the E-W component since February 1960. Adjusted to a 60-sec period, the pendulums yield curves with amplitude of 2 cm in the N-S direction and 4 cm in the E-W direction.

The second paper gives the first numerical results; the phases and observations of theoretical amplitudes of the M_2 , S_2 , N_2 , O_1 , K_1 terms and γ of the N-S component are tabulated for 2 epochs. The phases of the semidiurnal components are very weak. The amplitude ratios $\gamma=1+k-h$ are relatively high, probably due to indirect effects of the Atlantic Ocean. This can be separated from the direct effects when data become available for a longer period and for both components. — D. B. V.

- 187-143. Verbaandert, J., and Melchoir, P[aul] [J.]. La station de pendules horizontaux de Warmifontaine (Province de Luxembourg) [The horizontal pendulum station at Warmifontaine (Luxembourg Province)]: Acad. Royale Belgique Bull. Cl. Sci., ser. 5, v. 47, no. 5, p. 427-431, 1961.

The new underground earth tide station at Warmifontaine, near Neufchateau in Luxembourg Province, Belgium, is described and first results are presented. Comparison with those obtained at Sclaigheaux shows that the Warmifontaine installation is more stable; it is favored by its greater depth and by the physical nature of the bedrock. Further, the Sclaigheaux observations are somewhat affected by the level of the nearby Meuse River. — D. B. V.

- 187-144. Verbaandert, J., and Melchior, P[aul] [J.]. Les stations géophysiques souterraines et les pendules horizontaux de l'Observatoire Royal de Belgique [The underground geophysical stations and the horizontal pendulums of the Royal Observatory of Belgium]: Ciel et Terre, v. 76, no. 9-10, p. 249-278, and no. 11-12, p. 329-368, 1960; v. 77, no. 1-3, p. 17-67, and no. 4-6, p. 179-201, 1961.

Complete details are given concerning the earth tide stations in Belgium, particularly that at Sclaigheaux (see Geophys. Abs. 187-142), including a discussion of earth tides, the principles of construction of pendulums in general and of the new Belgian instruments in particular, the setting of the stations at Sclaigheaux (in Namur Province) and Warmifontaine (in Luxembourg Province), results obtained to date, and their interpretation. — D. B. V.

- 187-145. Ozawa, Izuo. On the observations of the earth tide by means of extensometers in horizontal components: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 46, p. 1-15, 1961.

The results of earth tide observations by means of extensometers at Osakayama, Suhara, and Matsushiro Observatories and at the Kishu mine are reported; the tide-constituents (M_2 , O_1 and so forth) of the observed strains were calculated by harmonic analysis. Results are in good agreement with the theoretical values calculated by use of the elastic moduli obtained from study of transmission of seismic waves. However, for analyzing an anomaly in the earth tide produced by anomalous structures in the crust, more precise observations are needed. — V. S. N.

- 187-146. Gougenheim, M. André. Confirmation, par l'observation, du rôle négligeable de la marée terrestre dans la production des séismes [Confirmation, by observation, of the negligible role of the earth tide in the production of earthquakes (with English summary)]: Annali Geofisica, v. 14, no. 2, p. 197-210, 1961.

This is virtually the same as the paper published in Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 21, p. 3313-3314, 1961 (see Geophys. Abs. 186-221). — D. B. V.

ELASTICITY

- 187-147. Rosenbaum, J. H. Refraction arrivals along a thin elastic plate surrounded by a fluid medium: Jour. Geophys. Research, v. 66, no. 11, p. 3899-3906, 1961.

An asymptotic solution is derived for the first arrival of significant amplitude and low frequency, which is refracted along a thin high-velocity plate surrounded by a fluid medium. This first arrival travels with approximately the velocity of a longitudinal plate wave in the refracting layer. The shape of the signal depends on the contrast (in density and elastic constants) between the plate and the fluid as well as on the distance (in units of plate thickness) that the signal has been refracted along the plate. Solutions in closed form are given. Cases of moderate contrast or long refraction path, large contrast and moderate refraction path, and intermediate contrast and path are treated. The case of an elastic plate shallowly submerged in a liquid half-space is considered in an appendix. — D. B. V.

- 187-148. Stoneley, Robert [S.]. The oscillations of the earth, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 239-250, 1961.

The problem of small oscillations of the earth is discussed. Lamb's solution for a uniform and incompressible sphere is summarized; Love's analysis for the statical deformation and the small oscillations of a uniform gravitating compressible sphere is outlined; and, finally, the problem of obtaining numerical values for the free periods of oscillation of the earth is treated. — V. S. N.

- Takeuchi, H[itoshi]. Torsional oscillations of the earth. See Geophys. Abs. 187-374.

- 187-149. Bortfeld, Reinhard. Seismic waves in a mathematical model of the surface layer: Geophys. Prosp., v. 9, no. 3, p. 350-369, 1961.

The surface layer is replaced by a layer in which the velocity changes linearly with the depth, i. e., by a transition layer. A plane irrotational wave of arbitrary shape travels vertically upward and hits this layer. The multiples produced by differential reflections in the layer and by reflections at the free boundary are computed. From the third order on, these multiples look exactly like empirical reflections. The sum of all multiples is the solution of the differential equations of the problem, and has some formal mathematical similarity to diffraction phenomena known from optics. — Author's abstract

- 187-150. Loeb, J. Attenuation des ondes sismiques dans les solides [Attenuation of seismic waves in solids (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 370-381, 1961.

The expression for acoustic wave propagation in formations that is yielded by laboratory experiments is not analogous to that of electromagnetic waves because the attenuation coefficient α is not independent of frequency; yet no

noticeable dispersion can be found with present recording technique. It is shown that these results are compatible if energy losses are accounted for by a hysteresis phenomenon, which is analyzed. The attenuation takes place without phase shift and consequently without dispersion.

The superposition principle is held to be inapplicable. It is predicted theoretically that a certain strain can completely cancel α . — D. B. V.

- 187-151. Thiruvengkatachar, V. R. Stress-wave propagation induced in an infinite slab by an impulse over a circular area of one face—I: India Natl. Inst. Sci. Proc., v. 26, pt. A, supp. 2, p. 31-47, 1960.

Explicit formulas are derived for determination of stress waves induced in an infinite slab of homogeneous, isotropic, perfectly elastic material, if at the instant $t=0$ an impulsive pressure of uniform intensity P is applied over a circular area of one of the faces of the slab. Approximate and simpler expressions for the same are derived also by application of the method of steepest descents. — V. S. N.

- 187-152. Asano, Shuzo. Reflection and refraction of elastic waves at a corrugated boundary surface. Pt. 1. The case of incidence of SH wave: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 177-197, 1960.

The propagation of SH waves normally incident on a corrugated boundary surface that can be expressed by one cosine term ($\xi=c \cos px$) is treated mathematically. The case can be represented by a Fourier series. The results are presented in tables and graphs. At certain values of L/L_S (L =wave length of corrugation, L_S =wave length of the incident SH wave), for example, $L=L_{S1}$ or $L=L_{S2}$, irregularly reflected or refracted waves become either comparable to or negligible in comparison with regular waves. The effect of the amplitude of the corrugation on the amplitude of a regularly reflected wave is opposite to and larger than its effect on a regularly refracted wave.

It is also found that, depending on L/L_S , there are waves that appear to propagate along the boundary surface because their amplitude decreases exponentially as distance from the boundary surface increases. — D. B. V.

- 187-153. Yoshiyama, Ryoichi. Propagation of surface waves and internal friction: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 361-368, 1960.

A discrepancy between theoretical results and those given by Sato (see Geophys. Abs. 174-61) in his paper on G-waves from the Kamchatka and New Guinea earthquakes is investigated mathematically. The internal friction constant $1/Q$ calculated from Sato's results increases remarkably with period T . This paper seeks reasonable unknown factors that disturb the generally used formula $A \propto (1/\sqrt{|\sin \theta|}) \exp(-k\Delta)$, where A is amplitude, θ is epicentral angular distance, Δ is distance traveled over the earth's surface, and $k=\pi/QVT$ (V =phase velocity). The factor $1/\sqrt{|\sin \theta|}$ in the formula is reexamined in an effort to deduce a characteristic friction $1/Q_0$ from the four series of apparent $1/Q$ values derived from Sato's results.

The definition of internal friction of the earth is still ambiguous; further studies of the attenuation constant of seismic waves are necessary. The value obtained in this paper is 4×10^{-3} , somewhat smaller than that expected from an earlier study by Yoshiyama (see Geophys. Abs. 185-139). — D. B. V.

- 187-154. Yoshiyama, Ryoichi. Stability of waves through a heterogeneous medium and apparent internal friction: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 467-478, 1960.

The relation of seismic wave attenuation to period is investigated by means of a mathematical treatment of the stability of a wave propagating through a heterogeneous medium. It is tentatively concluded that the effect of the periodic structure on the amplitude A of a progressive wave is represented by $A=1/\cos h\mu z$; therefore, the apparent internal friction $1/Q^1$ caused by the periodic structure should be somewhat smaller than that calculated on the assumption that A is a simple exponential function. — D. B. V.

- 187-155. Shima, Michiyasu. On the diffraction of elastic plane pulses by the crack of a half plane: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 45, p. 1-18, 1961.

A mathematical solution is given for the two-dimensional problem of the diffraction of plane elastic P- and S-pulses of a rectangular type by the crack of a half plane. Jones' (1952) method for the diffraction of a scalar wave in which the shorter pulse width is compared with the distance of the observation point from the edge of the crack is used. It is observed that the phase of a diffracted pulse is reversed at the shadow boundary, and that while the forms of the incident and reflected pulses are of rectangular type those of the diffracted P- and S-pulses are smooth. — V. S. N.

- 187-156. Volarovich, M. P., Levykin, A. I., and Sizov, V. P. Issledovaniye zatukhaniya uprugikh voln v obraztsakh gornykh porod [Investigation of attenuation of elastic waves in rock samples]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 8, p. 1198-1203, 1960.

A method of investigation of damping of elastic waves in rock samples under high confining pressure is proposed, and tests with a specially constructed generator of impulses of 1,000 cycles per second are reported. The method uses multiple reflections of ultrasonic impulses in cylindrical samples. Damping coefficients were measured for basalt, gabbro, marble, gabbrodiorite, quartz sandstone, syenite, granite, labradorite, aluminum, brass, and plexiglas samples. — A. J. S.

- 187-157. Rapoport, M. B. Kmetodike ul'trazvukovogo seysmicheskogo modelirovaniya [Method of ultrasonic seismic modeling]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 9, p. 1309-1315, 1960.

Problems of ultrasonic seismic modeling involving suppression of Rayleigh waves, preferential reception directions of the pickups, and formation of wave impulses are discussed. Methods for solving the problems are proposed and tested on solid two-dimensional models. It was found that an introduction of filters into the seismoscope suppresses free oscillations of piezocrystals and makes the form of wave impulses independent of their degree of damping, their contact with the model, and other factors. This secures a good reproducibility of the record form. The method proposed can be applied to three-dimensional models. — A. J. S.

- 187-158. Krayev, G. A., and Rel'tov, B. F. Zatukhaniye uprugikh voln na modelyakh treshchin [Attenuation of elastic waves in models of fractures]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 125-129, 1960.

An experimental method of study of fracturing of rocks is discussed, and the attenuation of induced elastic waves passing through models of such rocks is described. An elastic wave impulse apparatus constructed at Leningrad State University was used in the experiments, in which crystals of potassium sodium tartrate were employed as transmitters and pickups of ultrasonic oscillation. Results of the investigation are presented in graphical form. — A. J. S.

Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media. See *Geophys. Abs.* 187-252.

Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis. See *Geophys. Abs.* 187-251.

187-159. Key, F. A., Wright, J. K., Carpenter, E. W., Stott, B. M. H. Possible method for increasing the signal-noise ratio in the detection of the first motion of a refracted P-wave: *Nature*, v. 191, no. 4796, p. 1382-1383, 1961.

A basic problem in differentiating between small earthquakes and underground nuclear explosions is the detection of first motion when the amplitude of the signal is comparable with the microseismic background noise level at the quietest sites. If the noise is predominantly due to surface waves, the signal-noise ratio can be increased by placing the detector deep underground. By using two detectors, one at the surface and the other at a depth of, for example, a wavelength at the peak recording frequency, the signal at the surface detector can be regarded mainly as noise and subtracted from the other to give the required P-wave signal.

This suggestion has been tested by model experiments. Typical records are reproduced; the gain in S-N ratio is readily apparent. — D. B. V.

187-160. Koopmans, L. H. An evaluation of a signal-summing technique for improving the signal-to-noise ratios for seismic events: *Jour. Geophys. Research*, v. 66, no. 11, p. 3879-3893, 1961.

Formulas are derived for evaluating as a function of frequency the improvement in the root mean square signal-to-noise ratio for seismic events obtainable by the technique of summing the trace amplitudes recorded at a number of closely spaced seismometer stations. A modification of this technique whereby the signals are corrected for phase shift before summing is also studied. The theory is applied to noise data from a three-station network for the ranges of periods 6.7-20 sec and 0.25-1 sec. The signals in the short-period range are taken to be P- and S-body waves. Rayleigh waves are used in the long-period range. Improvement comparable to and occasionally in excess of that expected for uncorrelated noise is indicated for the modified technique in the short-period range, whereas little improvement is obtained in the long-period range for the given station spacing and noise conditions. — Author's abstract

187-161. Nakamura, Kohei. Normal mode waves in an elastic plate, pt. 2: *Tohoku Univ. Sci. Repts.*, ser. 5, v. 12, no. 2, p. 139-158, 1960.

Continuing the study of normal mode waves in an elastic plate, Nakamura investigates the structure of the dispersion curves of the normal mode waves formed by P- and Sv-waves in an elastic homogeneous plate with a Poisson's ratio of one-fourth by examining in detail the characteristic equations and by using the dispersion curves of a hypothetical plate that transmits only a single

body wave. Special emphasis is laid on the behavior of the dispersion curves at some particular angles of incidence of S and at the lattice points used by Tolstoy and Usdin (1956) in their study of group velocity of higher modes.

The frequency which makes the group velocity equal to the velocity of S and the maximum group velocity in higher modes, together with its corresponding frequency, are obtained as functions of mode number. For the most part, the lowest modes $\pi_0 \pm$ are not discussed, as their behavior is well known. — D. B. V.

- 187-162. Berg, Joseph W., Jr., and Cook, Kenneth L. Energies, magnitudes, and amplitudes of seismic waves from quarry blasts at Promontory and Lakeside, Utah: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 389-399, 1961.

The total apparent energy was computed for seismic waves on seismograms obtained at distances of 6.78 and 13.2 km from a blast of 1,221,000 lb of explosives and at 22.0 km from a blast of 2,138,000 lb of explosives at Promontory, Utah. Magnitudes ranging from 4.0 and 3.9 (charge size of 490,500 lb) to 4.6 and 4.4 (charge size of 2,138,000 lb) were computed from the data applicable at zero and 2 km from the large quarry blasts at Promontory and Lakeside between 1956 and 1959.

For charge sizes from 490,500 to 2,138,000 lb, an approximately linear relationship was found to exist between charge size and average record amplitude of the first cycle of the first arrival measured on vertical-component seismograms at Eureka, Nev. — D. B. V.

- 187-163. Kisslinger, C[arl], Mateker, E. J., Jr., and McEvelly, T. V. SH motion from explosions in soil: *Jour. Geophys. Research*, v. 66, no. 10, p. 3487-3496, 1961.

The fact that tangential horizontal motion that is not predicted by simple theory is prominent in almost all cases from both chemical and nuclear explosions was investigated experimentally. Seismograms recorded at small distances show asymmetrical radiation of SH motion in the source region, in contrast to the symmetrical pattern for the radial and vertical motion. This radiation pattern is the most useful indicator of the nature of the generating mechanism. The combined effect of charge size and depth determine which of two wave forms will appear. The most prominent SH motion is in the form of Love waves and is more pronounced for shallow shots that produce cratering or surface cracking than for completely contained shots. An examination of theoretical radiation patterns indicates that crack formation may contribute significantly to the generation of SH motion. — D. B. V.

- 187-164. Nodens, J. A. E. Tectonic leads in the coseismal-line spread of the Nevada underground nuclear detonation "Blanca": *Oklahoma Geology Notes*, v. 21, no. 9, p. 239-244, 1961.

A coseismal-line (equal time of P-arrivals) map of the Blanca detonation is presented, and a study of the pattern of spread of coseismal lines across the United States is discussed. The teleseismic stations selected for mapping of Blanca P-time arrivals are given in a table. The tectonic map of the United States (King, and others, 1944), used to correlate the spread pattern of the coseismal lines with the tectonic features, is also shown. Three distinct channels of seismic energy lead are noted: the axis of Alpidic-Variscan type orogeny of North America as seen in the NNW-SSE elongation of the line pattern over Washington, Oregon, Idaho, Nevada, Utah, California, and Arizona; the line spread from ground zero Blanca toward the Wasatch fault zone and

ENE through major structures to the line of the Champlain-St. Lawrence overthrust; and the line spread from ground zero Blanca eastward through structures in Utah, Colorado, Kansas, Missouri, Kentucky, and finally, tying in with the seismotectonic lead of the Appalachian orogenic belt through the fault system of the Allegheny Mountains. — V. S. N.

- 187-165. Karapetyan, B. K. Issledovaniye massovykh vzryvov dlya tseley inzhenenoy seysmologii [Investigation of massive explosions for the purposes of engineering seismology]: Akad. Nauk Tadzhik SSR Inst. Seismologii Trudy, v. 113, p. 7-13, 1959.

The effect of seismic waves from large explosions (0.35-30 tons) on engineering constructions was studied. The elastic oscillations of the ground were recorded by AIS-2 seismometers, which are described. The maximum reduced seismic accelerations from 0.017 to 16 g produced by the explosions were observed in the ground. Shooting several charges in a rapid sequence, the high frequency (0.01-0.3 sec period) of a single shot seismic wave can be transformed into a lower frequency seismic wave, which is more useful in seismic investigations. — A. J. S.

Research Group for Explosion Seismology. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 1. Explosions and seismic observations. Mikumo, Takeshi; Otsuka, Michio; Utsu, Tokuji; Terashima, Tsutomu; and Okada, Atusi. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 2. On the crustal structure. See Geophys. Abs. 187-364.

ELECTRICAL EXPLORATION

- 187-166. Van'yan, L. L., Terekhin, Ye. I., and Shtimmer, A. I. Metodika rascheta volnovykh krivyykh chastotnogo zondirovaniya [Methods of calculation of wave curves of frequency sounding]: Prikladnaya Geofizika, no. 30, p. 92-102, 1961.

The methods of calculation of the wave curves of frequency sounding in an n-layered medium over a basement of resistivities, $\rho_n = \infty$, $\rho_n = 0$, and $\rho_n \neq 0$, $\rho_n \neq \infty$ are worked out for 2-, 3-, and 4-layer profiles. Asymptotic formulas are developed for calculation of the right and left branches of the wave curves of frequency and magnetotelluric sounding. The method proposed requires neither summation of series nor numerical integration. More than 1,000 wave curves of frequency sounding in 2-, 3-, 4-, and 5-layer profiles were calculated by this method during the period from 1956 to 1960. — A. J. S.

- 187-167. Van'yan, L. L., Kaufman, A. A., and Terekhin, Ye. I. Raschet fazovykh krivyykh chastotnogo zondirovaniya sposobom transformatsii [Calculation of phase curves of frequency sounding by the method of transformation]: Prikladnaya Geofizika, no. 30, p. 103-114, 1961.

The apparent resistivity, ρ_ω , as determined by the method of frequency sounding is a complex function of circular frequency, ω , according to the equation $\rho_\omega = |\rho_\omega| e^{i\phi_\omega}$, where $|\rho_\omega|$ is the amplitude and ϕ_ω is the phase displacement of the electric or magnetic field. The method of trapezoidal frequency characteristics is suggested when the phase displacement, ϕ_{ω_k} , for the fre-

quency ω_k sought cannot be determined in elementary integrals. The process of determination of ϕ_{ω_k} by the method proposed is investigated mathematically. — A. J. S.

- 187-168. Glyuzman, A. M. Resheniye krayevoy zadachi dlya parabolicheskogo tsilindra v elektrorazvedke [Solution of the boundary problem for a parabolic cylinder in electrical prospecting]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 910-914, 1961.

The boundary problem of the spatial distribution of potential due to a point source located inside and outside a parabolic cylinder, whose surface separates two media of different electric conductivity, is treated mathematically. — A. J. S.

- 187-169. Molochnov, G. V. Ovozmozhnosti osushchestvleniya napravlennoy elektromagnitnoy zondirovaniya [On the feasibility of oriented electromagnetic sounding]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 915-916, 1961.

A method of oriented electromagnetic sounding is proposed. An alternating current of a certain frequency is passed through a frame antenna. A second reception frame antenna is installed within the generating antenna in a position where their centers coincide and their planes are perpendicular. The reception antenna is connected to a field recorder. Since no primary field of the generating antenna is received by the reception antenna, no field will be shown by the recorder if no conducting bodies or layers are present. Calculations of the secondary field show that its maximum is directed perpendicularly to the reception frame in the case of a layered medium of plane parallel boundaries. A similar orientation property of the secondary field was found for a spherical conducting body. — A. J. S.

- 187-170. Samosyuk, G. P., and Veshev, A. V. Pole tochechnogo istochnika toka v prisutstvii sfery [The field of a point-source current in the presence of a sphere]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 3-12, 1960.

This is a mathematical transformation of formulas for the potential of a point source of electric current in the presence of a conducting spherical body. To avoid the usual bulky solutions in the form of infinite series, cases are analysed where the conductivity of the spheres is equal to zero or infinity; this allows a closed solution of the problem. Based on this closed solution, other finite formulas for the potential and its gradient of a point-source current in the presence of a sphere of an arbitrary conductivity are developed. — A. J. S.

- 187-171. Veshev, A. V. Vliyaniye rel'yefa na rezul'taty rabot dipol'nym oseвым profilirovaniyem [Effect of relief on the results of work by dipole axial profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 13-35, 1960.

The effect of relief on the results of electrical axial dipole profiling is investigated experimentally and theoretically. Effects of mountain ridges and valleys with infinite and finite slopes and semispherical hollows are investigated, and their experimental curves of apparent resistivity ρ_k of dipole profiling are shown. It is found that relief affects the form of ρ_k curves, producing maximums and minimums similar to those produced by nonhomogeneities

in rocks and ore bodies of different conductivities. Although these two types of effects can generally be differentiated by qualitative considerations, their quantitative evaluation is possible in only a few specific cases. — A. J. S.

- 187-172. Semenov, A. S. Dipol'noye ekvatorial'noye profilirovaniye [Dipole equatorial profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 35-44, 1960.

The method of electrical dipole equatorial profiling is discussed, and apparent resistivity curves obtained experimentally on a model composed of metal and glass plates are shown. These curves are compared with other curves obtained on the same model by the methods of combined and axial dipole profiling. It was found that the equatorial electrical dipole profiling method may be used advantageously in combination with other methods, the axial dipole method in particular, rather than as a basic method of geoelectrical exploration. — A. J. S.

- 187-173. Ryss, Yu. S. Sopostavleniye anomalii yestestvennogo elektricheskogo polya s kharakterom i usloviyami zaleganiya rud po mestorozhdeniyam Rudnogo Altaya [Comparison of anomalies of the natural electric field with the character and the conditions of occurrence of ore deposits of the Rudnyy Altai]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 45-58, 1960.

The intensities of anomalies of the natural geoelectric field at 25 ore deposits in the Rudnyy Altai are compared with (1) mineralogical composition and structural-textural features of the ores, (2) character and thickness of oxidized and supergene zones, (3) thickness of friable deposits, (4) hydrology of the country rock, and (5) salinity of ore-deposit water. It was found that the depth of the mineral deposit and factors (1), (3), and (4) affect the intensity of the anomalies. — A. J. S.

- 187-174. Yakupov, V. S. Metod vertikal'noy sostavlyayushchey plotnosti toka [The method of vertical component of current density]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 59-62, 1960.

A method is proposed for study of e. m. f. in a vertically oriented section of a linear conductor induced by low frequency alternating current impressed into a grounded feeding line. Such a study allows an evaluation of the distribution of the vertical component of current density over the area investigated and therefore the structural nonhomogeneities in its geology. The applicability of the method was verified by field tests over biotite-granite country rock containing a series of chlorite-magnetite-cassiterite lodes. — A. J. S.

- 187-175. Veshev, A. V. Vliyaniye rel'efa na rezul'taty rabot kombinirovannykh elektroprofilirovaniyem [The effect of relief on the result of combined electric profiling]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 278, p. 83-108, 1959.

The results of theoretical and experimental studies of the topographic effect on the combined method of electric profiling are reported. The experiments were performed in two tanks containing water and finely ground clay. Direct current and an alternating current of 21 cycles per second were used for obtaining apparent resistivity curves for elongated forms of relief (a mountain range and a valley) and for isometric forms (concave and convex semi-

spheres and semispheroides). The method takes relief into account by applying to the actual relief a simplified experimental model relief based on the determined resistivity curve. The conditions under which the method proposed can be applied have not been investigated, but tests with the field curves indicate that a considerable reduction of the topographic effect can be obtained. — A. J. S.

- 187-176. Umezu, Naganori. Electrical prospecting method by three phase alternating current (Potential due to a uniform overburden) [in Japanese with English abstract]: Kyushu Inst. Technology Bull., no. 11, p. 19-27, 1961.

A new electrode configuration method, the three-phase alternating current method, for use in electrical prospecting is described and illustrated by several numerical calculations for a uniform overburden. By measuring the potential between the potential electrode and the electrical neutral point, and the three phase symmetrical currents between the three current electrodes, the resistivity between the equipotential surface that is in contact with the potential electrode and the electrical neutral point can be measured. A much wider area can be measured with one setup of this new configuration than with one of Wenner configuration. — V. S. N.

- 187-177. Umezu, Naganori. Electrical prospecting method by three phase alternating current (Potential due to a buried sphere) [in Japanese with English abstract]: Kyushu Inst. Technology Bull., no. 11, p. 29-34, 1961.

The three-phase alternating current method (see Geophys. Abs. 187-176) is applied to an approximate solution of the problem of the electrical potential due to a buried conducting sphere. Resistivity curves are plotted in terms of the radius and depth of the buried sphere, and from these the approximate depth and radius of the sphere are predicted. — V. S. N.

- 187-178. Boyd, D., and Roberts, B. C. Model experiments and survey results from a wingtip-mounted electromagnetic prospecting system: Geophys. Prosp., v. 9, no. 3, p. 411-420, 1961.

Model experiments at a scale of 1:200 were carried out in order to assess the performance of an E.M. system which was rigidly mounted on the wingtips of an aircraft. The experiments were performed over model conductors of various sizes, shapes, and resistivities. From the results the detectability of various natural-sized conductors was calculated. The results obtained over an unmined massive sulfide body in Cyprus are shown and a comparison made with the model results. — Authors' abstract

- 187-179. Terekhin, Ye. I., and Faradzhev, A. S. O svyazi rezul'tatov modelirovaniya nad stupen'yu s teoreticheskimi krivymi GVK [On the relationship of modeling results over a step, and the theoretical curves GVK]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 48-51, 1960.

The theory of GVK (horizontal-vertical contact) curves in electrical prospecting is discussed and compared with the results of modeling in a tank over a step. The graph presented in the paper shows good agreement between the experimental and theoretical data. — A. J. S.

- 187-180. Hallof, P[hilip] G. Uses of induced polarization in mining exploration: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 59L118, p. 319-327, 1960.

The large polarization effects used in prospecting techniques are a result of the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction; this type of polarization is called the "overvoltage effect." The usefulness of induced polarization as an exploration method is a result of the extreme sensitivity of the measurements to sulfide content in rocks. Methods of measurement and the instruments used are discussed, and actual field applications are described and illustrated. Field results show that induced polarization can be used to locate and outline the large disseminated sulfide zones characterized by the porphyry copper type ore bodies, to locate and extend some massive sulfide bodies that are too deeply buried to be detected by electromagnetic methods, and to evaluate electromagnetic conductors by separating metallic conductors from those due to electrolytic conduction zones. — V. S. N.

- 187-181. Ward, S[tanley] H. AFMAG: A new airborne electromagnetic prospecting method: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 59L119, p. 333-342, 1960.

The application of natural audiofrequency magnetic fields to the investigation of electrical properties of the subsurface has culminated in the development of an airborne prospecting device known as AFMAG (see Geophys. Abs. 179-151). The principles of the technique and methods of interpretation of data are discussed. Results of a test survey over the Whistle orebody and vicinity (Sudbury basin) are reviewed to illustrate the advantages of the method, particularly in rugged terrain. — V. S. N.

- 187-182. Breusse, J. J., and Astier, J[ean] L[ouise]. Étude des diapirs en Alsace et Baden-Würtemberg par la méthode du rectangle de résistivité [Study of the diapirs in Alsace and Baden-Würtemberg by the resistivity rectangle method (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 444-458, 1961.

The resistivity rectangle method of electrical surveying is described. This technique is a generalization of the fixed AB profile, in which the measuring electrodes MN are moved not only along the line AB, along a segment equal to the central quarter of AB, but also in the interior of a rectangle centered on the zero point of AB; the width of the rectangle is the above-mentioned segment and the length is $AB/2$. Measurements are made along a series of profiles parallel to AB, covering an area $AB^2/8$.

After stating the principles, procedure, and advantages of the technique, three examples of its application to salt domes are discussed. At Hetten-schlag-Oberentzen and Blodelsheim on the Alsace Plain and at Weinstetten-Heitersheim in Baden-Würtemberg, Germany, geologic conditions are similar (resistive alluviums, highly conducting marls, and resistive salt); the depth to the salt varies from 100 m to more than 1,000 m. Results are presented in resistivity maps, graphs of a few electrical soundings, and isobath maps to the top of the salt. Four drill holes subsequently confirmed the resistivity results. By increasing the current electrode spacing to 20 km, the effective depth of the method can be increased to 2,000 m or more. — D.-B. V.

- 187-183. Šumi, F[ranc]. The induced polarization method in ore investigation: Geophys. Prosp., v. 9, no. 3, p. 459-477, 1961.

It is shown that the decaytime of the polarization curve represents a characteristic property of polarized mediums and consequently of various ores. The decay times for various minerals, determined by laboratory measurements, are tabulated. Although the intervals of the decay times overlap somewhat, the decay time supplements induced polarization data. Interpretation in cases where the effects of bodies with different decay times are superposed is discussed. Examples from Sweden and Yugoslavia show that the induced polarization method can best be applied to finely disseminated ores; in some cases, especially on chromite and cinnabar deposits, it was the only geophysical procedure that yielded usable data. — D. B. V.

- 187-184. Porstendorfer, G[ottfried]. Automatische elektrische Drehsondierungen nach dem Wenner- und Dipolverfahren mit direkter Messwertregistrierung [Automatic electric rotating sounding by the Wenner and dipole techniques with direct registration of measured values (with English abstract)]: *Zeitschr. Geophysik*, v. 26, no. 6, p. 276-284, 1960.

Rotating electric sounding can be carried out without exchanging electrodes by means of a crossed Wenner arrangement, in which current electrodes perpendicular to each other are supplied with currents corresponding in values to the sine and cosine of the azimuth of sounding. In this case pertinent voltages over two pairs of crossed electrodes are automatically registered photographically according to direction and amount by a telluric vector recorder. A dipole arrangement with crosscurrent and voltage dipoles can be used to achieve greater depth of penetration. Supply current values are given as a function of azimuth. The coordinate recorder registers the field anisotropy, which can easily be transformed into anisotropy of apparent specific resistance. A few examples are given. — D. B. V.

- 187-185. Kovalenko, V. F. O primeneniі metoda registratsii perekhodnykh protsessov na kolchedannykh mestorozhdeniyakh Yuzhnogo Urala [Use of the method of registering of transition processes in pyrite deposits of the south Urals]: *Sovetskaya Geologiya*, no. 6, p. 89-101, 1961.

In order to increase the resolving power of the induction method of electrical prospecting for direct search for highly conductive ores, a study was made of the method using transition processes in a magnetic field. The substance of the method is as follows: Using any source (underground loop, magnetic dipole, or other) a constant magnetic field is created; then the current in the source field is cut off, and at that moment the transition process in the magnetic field is studied at various points of the area being examined. An advantage of this method is that only anomalous components of the field are measured. A schematic diagram is given for the apparatus, and examples with illustrations of use of the method in three commercial pyrite deposits are described. — J. W. C.

- 187-186. Bogdanov, A. Sh. Razvitiye rudnoy elektrorazvedki v blizhayshiye gody [Development of ore electrical prospecting in the coming years]: *Razvedka i Okhrana Nedr*, no. 7, p. 31-37, 1961.

Methods of electrical prospecting and their applications in the U.S.S.R. are summarized. Information is given on new designs of apparatus specified for electrical prospecting under various conditions and for various objectives. Suggestions for possible developments of methods and their application are given. — A. J. S.

- 187-187. Kochan, L. S. *Ustroystvo dlya etalonirovaniya elektrorazvedochnoy apparatury* [A device for standardization of electric prospecting apparatus]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 52-55, 1960.

An improved device for periodic standardization of electric prospecting apparatus is proposed for use in the field. A circuit diagram is given, and the procedure for standardization of oscillographs is discussed. This improved device economizes operational time and secures an accuracy within 1 percent for the M-45 device, class 1.0. — A. J. S.

- 187-188. Gross, Gerardo Wolfgang. Location of clay deposits by combined self-potential and resistivity surveys: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 60L2, p. 124-130, 1960.

A commercial deposit of white kaolinite clay in central Pennsylvania was successfully mapped by combined SP and resistivity methods, and results were checked by drilling. This investigation supports the hypothesis that certain SP phenomena may be ascribed to diffusion and membrane potentials produced by interaction of clay lenses, sandy matrix, and ground waters. Resistivity minimums in the range between 2,000 and 2,500 ohm-m and second-order SP maximums of 50-60 mv contrast characterize this deposit located beneath 30-40 feet of sandy overburden. — V. S. N.

- 187-189. Frischknecht, F[rank] C., and Ekren, E. B[artlett]. Electromagnetic studies of iron formations in the Lake Superior region: *Mining Eng.*, v. 13, no. 10, p. 1157-1162, 1961.

Experimental electromagnetic studies were made over several of the iron ranges in the Lake Superior region to determine if nonmagnetic oxidized iron formations in the Mesabi and Cuyuna ranges and the magnetic taconite in the eastern Mesabi and western Gogebic ranges could be detected. The oxidized iron ore beneath thick deposits of glacial drift could not be detected directly by the electromagnetic surveys. However, since graphitic or other conducting beds commonly associated with the hanging-wall of the oxidized formations can be readily located by the method, it should prove useful in mapping new ore. The magnetic taconite rocks are conductive over broad areas in the Mesabi and Gogebic ranges even under considerable thicknesses of glacial drift. Anomalies on electromagnetic profiles (slingram method) can be correlated from traverse to traverse, and if the stratigraphy is known on one traverse, it should be possible to trace lithology laterally for considerable distances. (See also *Geophys. Abs.* 183-222.) — V. S. N.

- 187-190. Melbye, Charles E. Resistivity method in groundwater exploration, city of Gunnison, Colo.: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L204, p. 328-332, 1960.

A resistivity survey was carried out in the western half of Gunnison, Colo., to investigate bedrock topography below unconsolidated gravels. The bedrock contour map produced was used in the selection of water-well sites. The satisfactory results in the Gunnison water program illustrate the favorable applicability of the resistivity method to similar ground water exploration problems. — V. S. N.

- 187-191. Cheriton, C. G. Anaconda exploration in the Bathurst district of New Brunswick, Canada: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L103, p. 278-284, 1960.

A successful exploration program for a massive sulfide deposit in the Bathurst district, New Brunswick, Canada, is described. The program was based on the use of geology and aerial photographs followed by airborne and ground electromagnetic surveys supplemented by some geochemical work. — V. S. N.

- 187-192. Fleming, H. W., and Brooks, R. R. Geophysical case history of the Clearwater deposit, Northumberland County, New Brunswick, Canada: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59L240, p. 131-138, 1960.

Comparative data are presented for the airborne magnetic, airborne electromagnetic, ground magnetic, and ground electromagnetic surveys over the Clearwater deposit, a massive-sulfide mineralization enclosed in an envelope of disseminated-sulfides. The effective penetration of the airborne electromagnetic equipment for deposits of this type is between 100 and 200 feet when flying at 400 feet above ground. It is possible that should a massive-sulfide deposit occur without an envelope of disseminated mineralization and have little or no out-of-phase response, it would either not be detected or would produce a poor anomaly. The airborne magnetic response was equally significant. All ground geophysical methods used could have led to the discovery of the massive-sulfide deposit, and all methods indicated the structural trend. The self-potential method, however, is not considered of great value for ground prospecting in this area. — V. S. N.

- 187-193. Mackay, D. G., and Paterson, N[orman] R. Geophysical discoveries in the Mattagami, Quebec: *Canadian Inst. Mining and Metallurgy Trans.*, v. 63, p. 478-484, 1960.

The geology of the Mattagami mineral camp, Quebec, Canada, is concealed by very thick overburden, and although the area has been prospected since early in the century, the first major sulfide discovery was made in 1956 as a result of a combined aeromagnetic and airborne electromagnetic survey. Since that time other bodies have been located by airborne and ground electromagnetic surveys for a total of five discoveries—the Mattagami, New Hosco, Garon Lake, Orchan, and Radiore. Routine airborne E. M. surveys at 1/4 mile spacing are capable of detecting about 50 percent of the small conductors in this area; surveys at 1/8 mile spacing seem to provide 100 percent detection. In ground surveys the horizontal loop E. M. is considered to provide the most information. All of the deposits are "good" conductors. Ratios of low to high frequency response in the airborne method are mostly over 1.0; the in-phase to out-of-phase ratio in the ground surveys is from 2 to 20 at the points of greatest response. The ore bodies contain significant sphalerite, but the combined pyrite and pyrrhotite content apparently is sufficient to constitute a good conductor. — V. S. N.

- 187-194. Keller, G[eorge] V., and Frischknecht, F[rank] C. Induction and galvanic resistivity studies on the Athabasca Glacier, Alberta, Canada, in *Geology of the Arctic*, v. 2: *Internat. Symposium Arctic Geology*, 1st, Calgary, Alberta, 1960, *Proc.*, p. 809-832, 1961.

A study of the use of electrical methods for measuring ice thickness on Athabasca Glacier, Alberta, Canada, is reported. Two methods for measuring resistivity were tested: (1) a conventional resistivity method in which current was fed galvanically into the glacier through electrodes; and (2) an electromagnetic method in which a wire loop laid on the ice was used to induce current flow. Both techniques were capable of measuring ice thicknesses up to 1,000 feet, the maximum thickness of the glacier. The electromagnetic

method was better for measuring ice thickness and resistivity of the rock underlying the ice, whereas the galvanic method was better for studying differences within the ice. — V. S. N.

- 187-195. Coster, F. M. Prospecting for groundwater, in *Underground water in Tanganyika: Dar Es Salaam, Tanganyika Department of Water Development and Irrigation, Chap. 8, p. 70-83, 1960.*

The field procedures and instruments used in resistivity surveys for ground water in Tanganyika are described, and an interpretation is given for several apparent resistivity curves from surveys in the basement rocks of Northern Province, younger lavas and pyroclastics, basement areas mainly in fault-zones in the Pare-Usambara region, and alluvial areas in the Kilosa-Kimamba region. In Tanganyika the resistivity surveys are found to be most useful in granitic areas, in coastal sedimentary rocks and unconsolidated sediment where salt-water penetration is liable to occur, and in tracing sandy alluvium under clays. Magnetic surveys have been used in Tanganyika to find dikes, kimberlites, and lavas, and to distinguish different rock types of the basement system where the overburden is heavy. On the whole they have not been found to be of great practical help in the location of water. — V. S. N.

- 187-196. Dam, J. C. van, and Rummelen, F. F. F. E. van. Resultaten van het geo-elektrisch onderzoek in vergelijking met de geologische opbouw van Zeeland [Results of the geoelectrical investigation in comparison with the geologic structure of Zeeland (with English summary)]: *Geologie en Mijnbouw*, v. 39, no. 11, p. 587-602, 1960.

As is to be expected in a marine estuarine region, a relationship exists between the lithologic sequence and salinity of the ground water in Zeeland province of the Netherlands. In many cases it is possible to determine sand-clay boundaries by electrical prospecting methods to depths of 200-300 m. Data from many borings show that the depth and configuration of the so-called "base layer" (Rupelian, middle Oligocene) as determined electrically agrees entirely with the actual stratigraphy. The top of the Maassilius beds of the Icenian also was located accurately. Fresh water deposits, even smaller ones, were also detected electrically. — D. B. V.

- 187-197. Nazarenko, O. V. Opyt primeneniya differentsial'nykh ustanovok pri morskikh elektrorazvedochnykh rabot na banke Makarova [Experience in the use of differential apparatus for marine electrical exploration on the Makarov Bank]: *Geologiya Nefti i Gaza*, no. 10, p. 44-47, 1959.

The Makarov Bank is a submarine mud volcano on the Baku Archipelago in the Caspian Sea. It was mapped by differential electrical exploration using an A_1MNA_2 and an A_1MBNA_2 apparatus. The profiles were 4.5-5.0 km long and 250-300 m apart. The boat moved at 10-12 km per hr. A map constructed on a basis of the profiles shows a clearly defined narrow zone of positive anomaly. This zone outlines an area of mud volcano deposits, which have a higher electrical resistivity than do the surrounding muds. — J. W. C.

- 187-198. Kim, Kyung Sik, and Kim, Young Cheol. Studies of the spontaneous polarization method at the Duckpoong coal field [in Korean with English abstract]: *Korea Geol. Survey Bull.*, no. 4, p. 116-127, 1960.

A spontaneous-polarization survey was made of the area of the Duckpoong coal field, Korea, to trace the alteration of the sediments where intruded by igneous rocks rather than to locate coal seams. The method was useful in delineating the geology of the area. — V. S. N.

Central Water and Power Research Station Poona. Geophysical investigations. See Geophys. Abs. 187-590.

ELECTRICAL LOGGING

- 187-199. Atkins, E. R., Jr., and Smith, G. H. The significance of particle shape in formation resistivity factor-porosity relationships: Jour. Petroleum Technology, v. 13, no. 3, p. 285-291, 1961.

Basic relationships that exist between the formation resistivity factor, F , and the porosity, ϕ , for naturally occurring particles in water solutions are reported. Laboratory tests on slurries of clay and sand show that the value m in the Archie expression $1/F = \phi^m$ is determined by the shape of the particles in the system. The value of m , the "shape factor," is constant for a system of particles of a given shape for a range of F - ϕ values. Applying this concept, the F - ϕ relationship can be predicted for mixtures of particles with different shapes, and these predicted relationships are useful in electric log interpretation. — J. W. C.

- 187-200. Bedcher, A. Z. Opredeleniye effektivnoy poristosti peschano-ale-vrolitsykh kolektorov po soprotivleniyu zony fil'tratsii [Determination of effective porosity of sandy-silty reservoirs by the resistivity of the zone of filtration]: Prikladnaya Geofizika, no. 30, p. 179-191, 1961.

An attempt is made to determine the total porosity, effective porosity, and noneffective porosity of oil and gas reservoirs from the resistivity curve of the zone of filtration. The quantitative interpretation is based on the assumption that saline water remains in the noneffective pores of the stratum instead of being displaced by the drilling mud filtrate. — A. J. S.

- 187-201. Kal'var'skaya, V. P. Sravnitel'nyy analiz odnokatushechnoy i dvukh-katushechnoy sistem v karotazhe magnitnoy vospriimchivosti i elektroprovodnosti [Comparative analysis of single-coil and double-coil systems in logging for magnetic susceptibility and electric conductivity]: Prikladnaya Geofizika, no. 30, p. 198-205, 1961.

A comparison is made between one- and two-coil systems of pickups used in magnetic susceptibility (κ) and electrical conductivity (σ) logging by the induction method. The one-coil system has several advantages over the two-coil system in κ -logging while the two-coil system performs better in σ -logging. — A. J. S.

- 187-202. Makarov, A. N. Method KS i yego mesto v komplekse karotazhnykh rabot na ugol'nykh mestorozhdeniyakh [The KS method and its place in the complex of logging for coal deposits]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 63-86, 1960.

The resistivity logging method employed for determining the geologic-electrical profiles in coal-bearing areas is discussed in detail, and different procedures for application of the method to various coal deposits are evaluated.

Resistivity logging is recommended for specific coals such as brown, bituminous, subbituminous, lean, and common coals, and the various grades of anthracite. A number of borehole logs from coal-producing areas are given. — A. J. S.

- 187-203. Khanin, A. A. Sravnitel'nyye dannyye opredeleniya koeffitsiyenta gazonasyshchennosti porod metodami izucheniya kerna i promyslovo-geofizicheskimi issledovaniyami [Comparative data of determination of the coefficient of gas saturation of rocks by the methods of study of core and of geophysical logging]: Razvedka i Okhrana Nedr, no. 9, p. 21-25, 1961.

The gas saturation of reservoirs in the Gazly gas field was determined using laboratory study of cores and electrical logging. The results obtained by these two methods are approximately the same for uniform sandy-silty rocks. Where sandy and clayey rocks are interbedded, however, the values obtained by electrical logging are always lower than those determined on cores. — J. W. C.

- 187-204. Per'kov, N. A. Okompleksei metodike promyslovo-geofizicheskikh issledovaniy karbonatnykh kollektorov [Combination and method of geophysical logging investigations of carbonate reservoirs]: Geologiya Nefti i Gaza, no. 6, p. 45-47, 1959.

Although electrical logging is suitable for determining porosity of sandy and shaly sections, it is inadequate for carbonate reservoirs. In limestone sections, SP anomalies occur opposite both porous and massive beds. Highly porous oil-bearing limestone commonly shows a lower resistivity than does massive, water-bearing sandstone or dolomite. Therefore, standard electrical logs must be supplemented by radiation logs and neutron-gamma logs. If a fractured limestone is shaly, a microlog must be made in addition. — J. W. C.

- 187-205. Vil'kov, N. V. Opredeleniye pronitsayemosti neftenosnykh i vodonosnykh plastov po PS [Determination of permeability of oil-bearing and water-bearing strata according to SP]: Geologiya Nefti i Gaza, no. 7, p. 45-47, 1959.

Data on the average permeability of oil- and water-bearing strata of Devonian age in western Bashkir A. S. S. R. and southeastern Tatar A. S. S. R. are compared with data on porosity determined by SP opposite these rocks. A satisfactory relationship is found between the two sets of values; this relationship is illustrated in graphs. The accuracy of the method is found to be higher than that of other methods. — J. W. C.

- 187-206. Aksel'rod, S. M. Analiz raboty zonda induktsionnogo karotazha pri nastroyke v rezonans tsepey priyemnykh i generatornykh katushek [Performance analysis of an induction logging sounding device when the receiver and generator coil circuits are tuned in resonance]: Prikladnaya Geofizika, no. 30, p. 206-214, 1961.

By an approximate method of mathematical analysis the character and the order of the effect due to the system of coils being installed in resonance in the apparatus for induction logging are determined. The resonance tuning of the circuits of the generator and pickup coils in the apparatus increases sensitivity in proportion to the square of the quality factors of the circuits and does not introduce distortion of signals that are dependent on the specific conductivity of the medium. — A. J. S.

- 187-207. Kinshakov, A. I., Sokhranov, N. N., and Solodunov, A. I. O che-tyrekh elektrodnykh zondakh, primenyayemykh v elektricheskoy karotazhe [On four-electrode sondes used in electrical logging]: Prikladnaya Geofizika, no. 30, p. 215-228, 1961.

A discussion is presented on the positioning of the electrodes A, M, N(B, A, M), and B(N) when the latter electrode is not removed to "infinity," but is placed near the borehole in which the electric logging is carried out. The optimum distance of the B(N) electrode is found to be not less than 140 d. — A. J. S.

- 187-208. Fatt, Irving. An electrodeless system for measuring electric logging parameters on core and mud samples: Jour. Petroleum Technology, v. 13, no. 3, p. 292-294, 1961.

A system for measuring electrical resistivity of liquids without use of electrodes offers interesting possibilities for electric logging technology. The apparatus is based on the principle that the solution being measured can form a loop coupling two transformer coils. For a fixed a-c voltage applied across one coil, the voltage appearing across the other is a function of the resistance of the liquid-filled loop. This electrodeless resistivity unit gives an accurate and instantaneous reading of drilling-mud resistivity. It can also be used in the laboratory for measuring the resistivity of cores. — J. W. C.

- 187-209. Knutson, C. F., Conley, F. R., Bohor, B. F., and Timko, D. J. Characterization of the San Miguel sandstone by a coordinated logging and coring program: Jour. Petroleum Technology, v. 13, no. 5, p. 425-432, 1961.

On a basis of induction electrical, microlog-caliper, and some velocity logs in conjunction with core study, a hydrocarbon-volume map was prepared of a portion of the San Miguel-1 reservoir, Sacatosa field, Texas. The producing sandstones prove to be very uniform throughout the drainage area of individual wells. Impervious zones generally disappear within a horizontal distance of 50 feet. — J. W. C.

- 187-210. Jordan, Louise. Salt in Wellington formation, Grant County, Oklahoma: Oklahoma Geology Notes, v. 21, no. 10, p. 272-274, 1961.

An investigation was made of the subsurface salt deposits in the Wellington formation near Medford, Okla., by examination of electric logs of wildcat tests drilled at an earlier time in the area and by a gamma ray-sonic-caliper and laterology survey of a new test hole drilled in Grant County in 1961. The total major salt section is from 812 to 928 feet below the surface; the thickest collective section is 42 feet and contains 69 percent salt. Correlation of the sonic log with the laterolog curves distinguishes clearly between the anhydrite and salt beds. — V. S. N.

- 187-211. Gorbenko, V. F. Detal'noye stratigraficheskoye razlicheniye verkhnemelovykh otlozheniy severo-zapadnoy okrainy Donbassa i uvyazka mikrofaunisticheskikh kompleksov s diagrammami standartnogo elektrokarotazha [Detailed stratigraphic subdivision of the Upper Cretaceous deposits of the northwest margin of the Donets Basin and correlation of the microfaunal assemblages with standard electric logs]: Akad. Nauk SSSR Doklady, v. 128, no. 3, p. 578-581, 1960.

A clear correlation between stratigraphic horizons established on the basis of microfaunal assemblages in the Upper Cretaceous of the northwest margin of the Donets Basin with those based on electric logging data suggests that the stratigraphic column established for that region can be used in petroleum prospecting and surveying. — D. B. V.

- 187-212. Adylov, F. T., and Mavlyanov, A. V. *Geologo-geofizicheskaya kharakteristika produktivnykh plastov paleogena mestorozhdeniya Zapadnyy Izbaskent* [Geological-geophysical characteristics of productive strata of the Paleogene of the Zapadnyy Izbaskent field]: *Uzbek. Geol. Zhur.*, no. 4, p. 41-45, 1961.

Resistivity and self-potential data are given for several stratigraphic units of the Zapadnyy Izbaskent oilfield of the Uzbek S.S.R. as determined from electrical logging. — J. W. C.

- 187-213. Mikaelyan, Sh. S. *Zavisimost' parametra poristosti ot koeffitsiyenta poristosti* [Dependence of the porosity parameter on the coefficient of porosity]: *Geologiya Nefti i Gaza*, no. 7, p. 39-44, 1959.

The porosity parameter is the ratio of the resistivity of the water-saturated reservoir to the resistivity of the water saturating the reservoir at formation pressure. The porosity parameter is related to the coefficient of porosity by a formula which must be determined for each field. A study of this relationship in the Berezovo oilfield is presented. The average value of the error in determining porosity according to the porosity parameter in this area is 7 percent. Greater accuracy can be obtained by improving the logging methods of resistivity measurement. — J. W. C.

- 187-214. Aliyev, A. G., Minzberg, L. V., and Nikolayeva, L. A. *Kollektorskiye svoystva porod Kirmakinskoy svity Apsheronskogo poluoostrova* [Reservoir properties of the rocks of the Kirmaki formation of the Apsheron Peninsula]: [Baku] *Akad. Nauk Azerbaydzhan. SSR*, 119 p., 1956.

This book provides data on the grain size, content of CaCO_3 , porosity, permeability, effective porosity, and hydraulic coefficients of rocks of the Kirmaki formation in the Apsheron Peninsula. The investigation was made on 2,311 cores and 678 specimens from outcrops. Tables of these parameters are given for various areas in the Kirmaki valley. — A. J. S.

EXPLORATION SUMMARIES AND STATISTICS

- 187-215. Cook, Douglas R. *Bonanza project*, Bear Creek Mining Company: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 59118, p. 285-295, 1960.

A case history of exploration for base metals in the Southern Bonanza mining district, Colorado, is presented. The exploration was based on the thesis (Burbank, 1947) that commercial deposits of metals might occur in Paleozoic sediments beneath the hydrothermally altered volcanic rocks of the Southern Bonanza district. Geological, geophysical (magnetic, gravity, scintillation), and geochemical studies were followed by the diamond drilling of 3 holes totaling 6,220 feet. The unusual thickness of the lava flows, possibly in a caldera structure, prevented exploration of the sediments beneath the flows and it

seems unlikely that Paleozoic sediments and major orebodies will be found at economic depths in the district. Ground magnetometer traverses were unsuccessful, probably because the extreme variations in magnetic susceptibility in the lava flows mask the subtle anomalies expected. The gravity survey results show no relation to any conceivable geologic or structural feature. A widespread radioactivity anomaly of low intensity is probably due to K^{40} because of the close correspondence of the anomaly to an area of intense sericitic alteration. — V. S. N.

- 187-216. Chapman, Robert M., and Sable, Edward G. Geophysical exploration, in *Geology of the Utukok-Corwin region, northwestern Alaska*. Part 3, Areal geology: U.S. Geol. Survey Prof. Paper 303-C, p. 145-151, 1960.

The Utukok-Corwin region includes about 7,500 sq mi in the western part of northern Alaska north of the De Long Mountains and east of the Chukchi Sea. Geophysical investigations consisting of seismic, gravimetric, and airborne magnetic surveys were included in the intensive exploration program of this area conducted from 1944-53 in and near the Naval Petroleum Reserve No. 4. Seismic reflection work north of the Utukok River at the headwaters of the Kaolak River and southward along the Utukok River into the southern foothills delineated two structurally distinct areas separated by the major south-dipping and west-trending Carbon Creek thrust fault. Two subsurface closed anticlines were mapped by the seismic method in the shallow Cretaceous system to the north. The Kaolak test well 1 was drilled on one of these. A gravity low lies northwest of Carbon Creek and north of the Utukok River; a gravity high coincides with the Carbon Creek fault zone. Magnetic intensity shows a general southwestward decrease. — V. S. N.

- 187-217. Sawatzky, H. B., Agarwal, R. G., and Wilson, W. Helium prospects in southwest Saskatchewan: Saskatchewan Dept. Mineral Resources Rept., no. 49, 26 p., 1960.

This is a longer version of the paper published in *Oil in Canada*, v. 12, no. 23, p. 54-76, 1960 (see *Geophys. Abs.* 182-224). Gravity, magnetic, and structural maps are included under separate cover in this report. — V. S. N.

- 187-218. Wdowiarz, Stanisław, Depowski, Stanisław, and Śliwiński, Zygmunt. *Badania geologiczne we fliszu Karpat i Bałkanów* [Geological investigations in the flysch of the Carpathians and Balkans]: *Przegląd Geol.*, v. 9, no. 5, p. 259-261, 1961.

A general geological discussion is presented of existing and desirable investigations of the flysch which extends over the territories of Czechoslovakia, Poland, and the U.S.S.R. in a belt tens of kilometers wide. The advantages of the gravimetric, magnetic, electrical, seismic, radiometric, and borehole logging methods of exploration of flysch and the possibility of discovery of new oil and gas fields by one or several combined geophysical methods are considered. — A. J. S.

- 187-219. Dąbrowski, Adam. *Zastosowanie metod geofizycznych w poszukiwaniu złóż rud żelaza w Polsce* [Application of geophysical methods in exploration for iron-ore deposits in Poland]: *Przegląd Geol.*, v. 9, no. 7, p. 371-374, 1961.

The history of exploration for iron deposits in Poland is reviewed. Various geophysical methods have been used in the areas of Niż Polski, Góry

Świętokrzyskie, and Dolny Śląsk. These explorations indicate that few iron deposits of economic significance are present in Poland. — A. J. S.

- 187-220. Vasil'yeva, V. G., ed. *Geologicheskoye stroeniye i neftegazonosnost' Yakutskoy ASSR* [Geology and oil-gas capability of the Yakutsk ASSR]: Moscow, Gostoptekhizdat, 478 p., 1960.

One chapter of this book (p. 315-400) is devoted to the results of geophysical investigations in the Yakutsk A. S. S. R. Density, magnetic susceptibility, and gamma activity are tabulated for more than 2,000 specimens; these comprise a great variety of sedimentary rocks and some igneous and metamorphic rocks.

Negative gravity anomalies predominate in the central part of the Yakutsk A. S. S. R. Six zones are distinguished, each of which is characterized by definite types of gravity anomalies. Gravity surveying has been very valuable in tectonic regionalization and in evaluating the structure of the crystalline basement.

The magnetic field of the eastern part of the Siberian platform is very inhomogeneous and is characterized by a large number of anomalies of different intensity, form, size, and trend. The character of the magnetic field changes considerably not only from one large structural element to another but also within individual regions.

Seismic reflection surveying has been successful in mapping third and fourth order structures where the amplitude is 250 m or more and the dips are sufficiently steep. Refraction surveying can be used to trace carbonate rocks where their depth does not exceed 5,000 m.

Several geoelectrical sections are described. Vertical electrical sounding has shown that permafrost is present nearly everywhere in the Yakutsk A. S. S. R. — J. W. C.

- 187-221. Boniwell, J. B., and McKenzie, A. M. Case history of the Corridor orebody, Mount Lyell, Tasmania: *Australasian Inst. Mining and Metallurgy Proc.*, no. 198, p. 281-297, 1961.

The Corridor copper sulfide deposit was discovered after a combination of geophysical prospecting methods had defined a target zone for diamond drilling. Anomalies outlined by Turam and self-potential surveys formed the basis for successful drilling. Vertical force variometer, vertical loop electromagnetometer, airborne magnetometer and scintillometer, AFMAG, gravimeter, induced polarization, and geochemical surveys also were tested over the area. This multipronged geophysical approach demonstrates that, although no one tool is versatile enough to meet the demands of every mineral setting, a combination of geophysical methods can be selected for a program that will attain optimum discrimination with speed and economy. — V. S. N.

- 187-222. Crary, A. P., and Van der Hoeven, F. G. Sub-ice topography of Antarctica, Long 60° W. to 130° E.: *Internat. Assoc. Sci. Hydrology*, Pub. No. 55 (*Internat. Union Geodesy and Geophysics*, Gen. Assembly, Helsinki 1960, *Symposium on Antarctic Geology*), p. 125-131, 1961.

Results of three traverses in interior Antarctica south and west of the Ross Sea are presented. For the most part the traverses were of exploratory nature and the main contributions came from the determinations of surface elevations, general snow character and annual accumulation, and ice thickness values; these last were measured by means of seismic, gravity, and magnetic

methods. Most of the area covered was found to have bedrock below sea level. Combining these results with those of other expeditions gives a clearer picture of the Atlantic horst, which rises 2,000-3,000 m above the land surface on either side. — D. B. V.

- 187-223. Carsey, J. Ben. Exploratory drilling in 1960: *Am. Assoc. Petroleum Geologists Bull.*, v. 45, no. 6, p. 701-727, 1961.

During 1960, a total of 11,704 exploratory holes were drilled in the United States; 2,189 of these, or 18.70 percent, produced some oil or gas. Of 7,320 new-field wildcats, 745 or 10.18 percent produced some oil or gas; of 1,953 new-pool tests 616 or 31.54 percent produced some oil or gas; and of 2,431 outposts, 828 or 34.06 percent produced some oil or gas. Total exploratory footage in 1960 was 55,830,684 feet, an average of 4,770 feet per hole. In 1959, a total of 63,252,521 feet were drilled in 13,191 holes, with an average depth of 4,795 feet.

Although 11-12 percent of all new-field wildcats are "successful," only about 2 percent discover a profitable field. Data on Canada and Mexico are also given in this report. — D. B. V.

GENERAL

- 187-224. Helliwell, R. A., and Martin, L. H. The international geophysical month: *Science*, v. 134, no. 3492, p. 1737-1738, 1961.

The concept of International Geophysical Months is suggested. These would consist of three to four weeks of very intensive observations of geophysical phenomena, followed by detailed analysis of the data. The advantages of such concentrated short-term programs, supplementing the long synoptic programs characteristic of the International Geophysical Year, are discussed. — D. B. V.

- 187-225. Piskunov, L. I. Issledovaniye yavleniy relaksatii [Investigation of relaxation phenomena]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 905-909, 1961.

This paper analyzes a set of n homogeneous exponential processes of relaxation, such as decay of radioactive elements and isotopes, attenuation of elastic waves, and nuclear relaxation in magnetic nuclear resonance, which in the absence of interaction and intensity drop can be represented as

$$F(t) = \sum_{i=1}^n A_{oi} \exp(-k_i t)$$

where A_{oi} is the greatest intensity value of individual components of the process, $k_i = 1/\tau_i$ is a parameter which characterizes velocities, and τ is the relaxation time. The analysis is directed toward determination of A_{oi} and τ_i values of rocks, and subsequent evaluation of their physical parameters. — A. J. S.

- 187-226. Shaub, Yu. B. Vydeleniye geofizicheskikh anomalii na fone intensivnykh pomekh [Distinguishing geophysical anomalies on a background of intensive interferences]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 898-904, 1961.

A new method is proposed for distinguishing geophysical anomalies from background noise when the anomalies are smaller than the mean error of observation. Based on the summation of the total signal by the alternate sign

process, this method increases the ratio of the total signal amplitude to the interference signal by $n^{\frac{1}{2}}$, where n is the number of readings in the summation. A simple electronic apparatus is proposed for automatic processing of the alternate sign signal summation. — A. J. S.

- 187-227. Paarma, Heikki, and Marmo, Vladi. Eräistä suurrakenteista Suomen geologiaan sovellettuina [On some large structures with application to the geology of Finland (with English abstract)]: Terra, v. 73, no. 2, p. 78-86, 1961.

Recent theories on global structural problems proposed by Belousov, Khain, Peive, and others are reviewed briefly and compared with the results of geologic and geophysical studies (seismic, gravity, and aeromagnetic) in Finland. Attention is called to the orientation of the eskers in Finland that obviously reflect the tectonic structure. Possible application of the tectonic data for ore exploration is also discussed. — V. S. N.

- 187-228. Moody, Graham B., ed. Petroleum exploration handbook: New York, McGraw-Hill Book Company, Inc. 829 p., 1961.

The purpose of this handbook is to summarize and to correlate all the activities involved in petroleum exploration. The twenty-five chapters, each by different authors, discuss fundamental concepts of exploration, the application of earth sciences and various techniques to petroleum exploration, and the implementation of an exploratory project from the original planning to the drilling and logging of an exploratory well. Finally, the extremely important complementary activities, such as laboratory procedures, in exploration are covered. In chapter 11, seismic, gravimetric, and magnetic methods of exploration for petroleum are discussed. Chapters 19, 20, and 21 discuss electrical logging, radioactivity well logging, and miscellaneous well logs, respectively. A six page bibliography and four appendixes of tabulated geological, mapping and surveying, and mathematical information are included. — V. S. N.

- 187-229. Gratsianova, O. P., ed. Spravochnik geofizika. Stratigrafiya, litologiya, tektonika i fizicheskiye svoystva gornyykh porod [Reference book of geophysics. Stratigraphy, lithology, tectonics, and physical properties of rocks]: Moscow, Gostoptekhzdat, 636 p., 1961.

This is the first of four planned volumes devoted to stratigraphic, lithologic, and tectonic data, and to information on the forms and physical properties of oil and gas pools. The handbook contains data needed for planned geophysical investigations in various regions of the U.S.S.R., preparation of geological reports on geophysical exploration in these regions, and interpretation of the geophysical data obtained. Tectonic and morphologic characteristics favorable for accumulation of natural gas and oil are given for specific regions. The last chapter is devoted to methods of determination of specific gravity, porosity, permeability, apparent electrical resistivity, salinity of formation water, coefficient of membrane potential, grain size, and magnetic and elastic properties of minerals and rocks. — A. J. S.

- 187-230. Pemberton, Roger H. Combined geophysical prospecting system by helicopter: Am. Inst. Mining Metall. Petroleum Engineers Trans., v. 217, Tech. Paper 59L33, p. 388-393, 1960.

The helicopter, outfitted with magnetic, electromagnetic, and radioactivity recording equipment, is an advanced and efficient aerial geophysical tool. This equipment has overcome a large number of the problems that were encountered in other airborne geophysical surveys and provides (1) responses across the entire conductivity-size band, (2) coincident and simultaneous recordings of both the magnetic and electromagnetic responses on the same record, (3) better resolution of electromagnetic and magnetic results, and (4) greater control of the positioning of data so that subsequent ground follow-up work will be at a minimum. The greatest limitation of the system is that it is still capable of exploring only to a finite depth. — V. S. N.

187-231. Marmo, V[ladi]. *Nykyaikaisesta malminetsinnästä* [On modern prospecting]: Terra, v. 73, no. 3, p. 123-132, 1961.

Methods of prospecting for mineral deposits as practiced in Finland are described briefly in the following order: airborne magnetic and radioactivity, diamond drilling, geochemical, ground electromagnetic (slingram), drill hole (three-component magnetometry), radioactivity, and other methods. — V. S. N.

187-232. Buyalov, N. I., and Zabarinskiy, P. P. *Poiski i razvedka neftya-nykh i gazovykh mestorozhdeniy* [Exploration and prospecting for oil and gas fields]: Moscow, Gostoptekhizdat, 450 p., 1960.

This book on oil and gas exploration contains a section devoted to geophysical methods. Gravity, magnetic, electrical, seismic, and radiometric surveying are discussed separately, and then their combined and coordinated use is treated. — J. W. C.

187-233. Shmidt, O. Yu. *Izbrannyye trudy* [Collected works]: Moscow, Akad. Nauk SSSR, 210 p., 1960.

This volume contains collected works on geophysics and planetary cosmogony. The papers are devoted to the origin of the earth and its magnetic field, the age of the earth, the core of the earth, and variometer surveying. — J. W. C.

GEODESY

187-234. Kivioja, Lassi. Some expected results caused by the melting of land-supported ice caps, in *Geodesy in the space age* (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 137-139, 1961.

The effect on the continental shorelines of total melting of present land-supported ice masses is calculated, assuming that the earth is plastic. It is found that with complete isostatic compensation the surface of the oceans would be 28.4 m higher and the continents 29.6 m higher so that shorelines would be 1.2 m lower. The ground under the former ice would be 471 m higher. The geoid would be 28.4 m higher on the oceans and would rise at the continental shore lines; it would sink in icecap areas when the ice is removed but would start to rise as isostatic uplift took place. Gravity on the oceans would change by -7.5 mgal (taking only Bouguer and free air anomalies into account).

The pear-shaped earth may be caused by accumulation of material under the M-discontinuity around areas pressed down by continental ice masses. If Antarctica started to rise after removal of its ice load, this accumulated subcrustal material would be the first to flow back; the surrounding ocean floor would sink faster than in the rest of the world, making room for part of the melt waters, and the continental area would thus increase.

Perfect isostatic compensation is not claimed, but for large masses such as oceans and continents it is only a question of time when perfect equilibrium is approached. — D. B. V.

- 187-235. Baussus, Hans G. Some new aspects regarding the estimation of field variables in meteorology and physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 140-147, 1961.

The first part of this paper discusses the use of dynamic equations including eddy viscosity terms in attacking problems of dynamic weather forecasting. Then it is shown that it is possible to derive the basic structures of an estimation theory through the use of a flow model for the earth's interior. Equations are given that refer to the cogeoid for which the topographic influences have been correlated out so that the flow model extends to the surface. — D. B. V.

- 187-236. Tengström, Erik. A comparison between the methods of Stokes, Molodenskij, and Hirvonen in physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 148-151, 1961.

Results obtained with the Stokes, Molodenskij, and Hirvonen methods of computing the geoid from gravity anomalies have been compared by using models with constant density but different shape. The use of high speed computers has made it possible to give the internal and external potentials of rather complicated models. The solutions obtained for a circular cone having a height of 4 km and a radius of 12 km suggest that both the Stokes method, using Rudzki anomalies and restoring the topography, and the Molodenskij method, starting from the Stokes and Vening Meinesz formulas, seem to agree very well with the true values. There is still some doubt as to the degree of approximation of Hirvonen's expressions; computations for steeper models should throw light on their degree of accuracy. — D. B. V.

- 187-237. Lambert, Walter D. The significance of the geoid, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 151-154, 1961.

Gravimetric geodesy has introduced new and valuable ideas and has caused modification of some earlier ideas, but among the ideas worth keeping is the concept of the geoid. This concept has three advantages: (1) the advantage of thinking in small numbers; (2) the fact that we know or can know directly the form of the geoid as a physical reality over most of the earth's surface; and (3) the geophysical implications of a knowledge of the geoid. — D. B. V.

- 187-238. Heiskanen, W. A. Achievements of physical geodesy, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 154-159, 1961.

The activity of the Columbus group, which has worked continuously for a decade with the problems of physical geodesy, is reviewed. Work has proceeded in four main fields: collecting and analyzing gravity material; computing the quantities N , ξ , and η at the geoid; computing the corresponding quantities N_h , ξ_h , and η_h at different elevations; and performing theoretical studies. The main problem of physical geodesy at present is to fill the big gaps in the gravity anomaly field. The method itself is perfect; that the present accuracy is not yet as high as desired is due to the incompleteness of gravity data. — D. B. V.

- 187-239. Iszak, Imre J. A determination of the ellipticity of the earth's equator from the motion of two satellites, in Research in space science: Smithsonian Inst. Astrophys. Observatory Spec. Rept., no. 6, p. 11-24, 1961; abstract and discussion, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 166-167, 1961.

On the basis of the Baker-Nunn observations of the satellites 1959 α 1 and 1959 η , the coefficient β , interpreted as the ellipticity of the earth's equator, and the phase constant λ_0 , which gives the geographic longitude of the long equatorial axis, are calculated as $\beta = (3.21 \pm 0.29) \times 10^{-5}$ and $\lambda_0 = 33.15^\circ \pm 0.53^\circ$ W. The difference between the long and short semi-axes is $a_1 - a_2 = 408$ m. — D. B. V.

- 187-240. Kaula, William M. The interaction between geodesy and the space sciences, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 168-173, 1961.

Exploitation of satellites and their orbits yields an improved description of the gravitational and geometrical variations of the earth's exterior, and theories of planetary interiors and their evolution are assisted by knowledge of possible mass distributions within the earth. Discussion of these interactions of geodesy and space science leads to the conclusion that the source of the long wave components of the observed gravity field is probably in the lower mantle. If so, a plausible theory is needed to explain the variability of wavelengths of the gravity field too short to have such a deep source. Many geodetic considerations bear immediately on what is plausible. — D. B. V.

- 187-241. Thomas, Paul D. The dual role for geodesy in the space age, in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 176-183, 1961.

New tools, such as artificial satellites, are being used for research in the fundamental problems of geodesy. The new microwave distance measuring equipment, in combinations with classical instruments and ingenious new observing techniques, provides the very accurate ground control required for many space projects. — D. B. V.

- 187-242. Hirvonen, R. A. New theory of the gravimetric geodesy: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 9, 50 p., 1960.

This is a reprint of the paper originally published in Acad. Sci. Fennicae Annales, ser. A-3, no. 56, 50 p., 1960 (see Geophys. Abs. 183-311). — V. S. N.

- 187-243. Zabek, Z. Problème de l'introduction du système des déviations gravimétriques de la verticale à la compensation du réseau astronomique et géodésique du pays [Problem of introducing the system of gravimetric deflections of the vertical into the compensation of the astrogeodetic network of the country]: Bull. Géod., no. 61, p. 213-243, 1961.

Mathematical treatment of the problem stated in the title of this paper leads to the following conclusions: (1) In some European countries the available gravimetric data, together with suitable choice of parameters of geodetic and

gravimetric references, permit simultaneous compensation of the astrogeodetic network and of the system of plumbline deflections by means of equations which are given. (2) The gravimetric determination of deflections of the vertical for n Laplace points gives rise to $(2n-m)$ superabundant observations, where m is the number of unknowns in the equations; introduction of these observations into compensation of the base network increases the precision of the compensated values of astronomic and gravimetric geodetic elements. (3) As astronomically observed latitudes are not compensated during compensation of the astrogeodetic network, the north-south components of deflections of the vertical are affected by observational errors in astronomical determinations of latitude. (4) The corrections obtained by compensation are valuable in analyzing the accuracy of astronomical determinations of latitude and longitude and of gravimetric deflection of the vertical. (5) The unknowns x and y with indices of 0 to 3 or 5, obtained by the compensation, constitute a basis for transforming the gravimetric deflection of the vertical at any point in the region studied into the geodetic coordinate system, thus providing a convenient way of obtaining a uniform system of deflections of the vertical over every expanse covered by the astrogeodetic network. — D. B. V.

- 187-244. Fischer, Irene. The present extent of the astro-geodetic geoid and the geodetic world datum derived from it: *Bull. Géod.*, no. 61, p. 245-264, 1961.

Since presentation of the Hough ellipsoid in 1957 (see *Geophys. Abs.* 180-188), the astrogeodetic geoid has been extended into the Caribbean, India, and Japan. The two hemispheres have been tentatively connected across the North Atlantic by a reasonable assumption about the unknown geoid profile there. A series of solutions has been made for a world ellipsoid and world datum, with and without enforcing the flattening of $1/298.3$ and with and without gravimetric orientation. The resulting ellipsoids are very small, with an equatorial radius of about 6,378,160 m. The agreement between astrogeodetic and gravimetric geoid profiles is greatly improved by the small ellipsoid (see also *Geophys. Abs.* 182-250). — D. B. V.

- 187-245. Modrinskiy, N. I. *Geodeziya* [Geodesy]: Leningrad, Hydrometeoizdat, 449 p., 1960.

This is a textbook on geodesy for students of hydrometeorology. The emphasis is put on the use of topographic maps, ability to level and survey medium-sized areas, and theoretical problems of phototopography and photogrammetry. Instructions on practical training are reserved for special manuals on geodetic field work. — A. J. S.

- Woollard, George P[ryor]. The status of gravimetric control for global geodetic studies. See *Geophys. Abs.* 187-309.

- Uotila, Urho A. [K.]. Existing gravity material. See *Geophys. Abs.* 187-308.

- Kozai, Yoshihide. The motion of a close earth satellite. See *Geophys. Abs.* 187-284.

GEOTECTONICS

- 187-246. Bernal, J. D., Dietz, Robert S., and Wilson, J. Tuzo. Continental and oceanic differentiation; *Nature*, v. 192, no. 4798, p. 123-128, 1961.

This is a discussion provoked by Dietz's recent paper on spreading ocean floors (see *Geophys. Abs.* 186-352). Bernal draws attention to two difficulties that are still unexplained: the first concerns the depth of the asthenosphere, and the second the mechanism of geochemical differentiation between sima and sial. Dietz answers the second objection to Bernal's satisfaction by suggesting that the sima rising from the deep mantle contains some juvenile sialic material; by spreading, this material is eventually slid under the continents, where the sialic fraction is squeezed out (gravitationally differentiated) and plastered to the underside of the continent. Concerning the first, however, Bernal insists that deep-focus earthquakes cannot represent merely temporary accumulations of stress in a long-term easy creep material, but must mean that not only the lower crust but also the rigid upper mantle down to about 900 km must move with the continents.

Wilson comments that paleomagnetic results confirm the flow of mantle currents inferred in Dietz's theory and also in that of Hess, and that certain puzzling features of island arcs and differences in length between older and recent mountain systems are accounted for in the new theories. Movements of continents would cause a change in the principal moments of inertia of the earth and thus produce polar wandering. Collision of continents might produce migrating waves of uplift that could explain some isolated and far-reaching overthrusts. Neither Dietz nor Hess, however, satisfactorily accounts for the thickening and uplift necessary to prevent drowning of the crust beneath the sea; it is suggested that slow expansion of the earth (a few mm per yr) not only would not interfere with, but indeed would assist the other orogenic processes. — D. B. V.

- 187-247. Hamilton, Warren [B.]. Origin of the Gulf of California: *Geol. Soc. America Bull.*, v. 72, no. 9, p. 1307-1318, 1961.

Crustal structure of most of the Gulf of California is of oceanic type, so that an origin by structural depression of continental rocks is not possible. Examination of the structural features north and south of Los Angeles suggests that Baja California originally lay 300 miles to the southeast, against the continental-margin bulge of Jalisco; the Gulf of California may be a pull-apart feature caused by strike-slip displacement plus up to 100 miles of cross-strike separation of the continental plate, subcontinental materials having welled up into the rift gap. The strike-slip motion has a tensional component across the continental margin south of Los Angeles but a compressional component to the north. — D. B. V.

- 187-248. Cook, Melvin A., and Eardley, A[rmund] J. Energy requirements in terrestrial expansion: *Jour. Geophys. Research*, v. 66, no. 11, p. 3907-3912, 1961.

The gravitational energy requirements of terrestrial expansion are calculated to be 6×10^{37} ergs over 225 million years in Egyed's model and 5×10^{38} ergs in Carey's model (see *Geophys. Abs.* 167-165, 178-217, respectively). Chemical energy is shown to be inadequate to produce expansion in either model. Uniform radioactive heating is too low for Carey's model but might fit Egyed's requirements. Phase changes likewise are shown to be inadequate for appreciable expansion. Upward and downward propagation of phase bound-

aries due to glacial loading and unloading, and consequent isostatic adjustments, are shown to be improbable. It is concluded that the earth could not have expanded to the extent proposed by some of the advocates of continental separation. — D. B. V.

- 187-249. Lyustikh, E. [Ye.] N. The energy of gravitational differentiation of the earth's mantle: *Annali Geofisica*, v. 14, no. 2, p. 169-172, 1961.

The crust has formed as a result of gravitational rise of sialic material differentiated from the mantle. The resulting mean supply of energy for tectonic forces might be as much as 10^{23} - 10^{27} ergs per yr. The energy of all tectonic processes is estimated at 10^{24} - 10^{31} ergs per yr. Therefore, the mechanism of differentiation could be the source of tectonic energy. — D. B. V.

- 187-250. Halushko [Galushko], P. Ya. Pro mozhyvosti vyvchennya vertykal'nykh rukhiv zemnoyi kory za anomal'yamy sylatyazhinnya [On the possibility of studying vertical movements of the earth's crust by means of gravity anomalies (in Ukrainian)]: *Akad. Nauk Ukrayin RSR Heol. Zhur.*, v. 20, no. 3, p. 96-101, 1960.

This is essentially a review of Russian work pertaining to the determination of vertical crustal movements from regional gravity anomalies, particularly that of Lyustikh and Subbotin (see *Geophys. Abs.* 136-10753, 163-1, respectively). Crustal structure should be ascertained first; then the nature and cause of vertical movements can be interpreted from the gravity data. — D. B. V.

- 187-251. Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis: *Geol. Soc. America Bull.*, v. 72, no. 11, p. 1595-1620, 1961.

This paper presents an introduction to the theory of folding of stratified viscoelastic mediums under compression and discusses its significance in the context of tectonics and orogenesis. After a discussion of the buckling of an elastic rock that is under axial compression and is restrained laterally by viscous dashpots, the analysis proceeds to the analogous problem for an elastic and a viscous plate surrounded by a viscous medium. Results of some more complex problems previously analyzed by Biot are also applied and discussed.

A new feature of this approach is the emphasis on rate phenomena and time histories in tectonic folding. The theory leads to the concept of dominant wavelength and band width selectivity in analogy with the theory of electric wave filters. The theory is applied to specific examples of geologic interest. Using accepted values of rock viscosity and elastic moduli, the time required for significant folding to take place agrees very well with the geologic time scale.

It is concluded that the viscous mechanism tends to predominate in tectonic folding. Theoretically the wavelength of the folds will not be sensitive to the magnitude of the tectonic stresses unless gravity forces become important. The calculated wavelengths are in good agreement with the range of observed values. — D. B. V.

- 187-252. Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media: *Geol. Soc. America Bull.*, v. 72, no. 11, p. 1621-1632, 1961.

An experimental check has been obtained for the theory presented in the companion paper (see Geophys. Abs. 187-251). Model tests have been conducted for both an elastic layer and a viscous layer embedded in a viscous medium and subject to a compression parallel with the layer. The appearance of the folds and measured wavelengths are in good agreement with the theoretical predictions. A theoretical evaluation of the time history of deformation for a layer whose folding develops from a given initial departure from perfect flatness is given. — D. B. V.

- 187-253. Beloussov [Belousov], V. V., and Ruditch [Rudich], E. [Ye.] M. Island arcs in the development of the earth's structure (especially in the region of Japan and the Sea of Okhotsk): Jour. Geology, v. 69, no. 6, p. 647-658, 1961.

This is an English version of the paper published previously in Sovetskaya Geologiya, no. 10, p. 3-23, 1960 (see Geophys. Abs. 184-346). — V. S. N.

- 187-254. Beloussov [Belousov], V. V. Development of the earth and tectogenesis: Philippine Geologist, v. 15, no. 1, p. 27-58, 1961.

This is a reprint of the paper published in Jour. Geophys. Research, v. 65, no. 12, p. 4127-4146, 1960 (see Geophys. Abs. 184-345). — V. S. N.

- 187-255. Brunn, Jan Houghton. Origine et localisation de l'énergie de la granitisation [Origin and localization of the energy of granitization]: Acad. Sci. [Paris] Comptes Rendus, v. 252, no. 22, p. 3470-3472, 1961.

It is suggested that the energy transfer from deep to more superficial layers required for granitization of sediments, generally attributed to geosynclinal subsidence, is governed by updoming of the crystalline crust. The resulting decompression of underlying layers would permit the release of their volatile elements, which could then rise toward the surface. This concept agrees better with the observed facts (anticlinal batholiths, for instance) than does the subsidence concept. The relaying of subcrustal internal pressure by orogenic compression accounts for the liberation of the latent energy of magma and its transfer to shallow zones. — D. B. V.

- 187-256. Gorshkov, G. S. Petrochemistry of volcanic rocks in relation to the formation of island arcs: Annali Geofisica, v. 14, no. 2, p. 137-144, 1961.

Lavas of oceanic islands are alkalic, and those of continental areas and island arcs are calc-alkalic; each is related genetically as well as spatially to its corresponding crustal type. Oceanic magma of hawaiian type is ancestral to all other types; in the course of normal evolution it becomes progressively more alkalic, and on contamination by sialic material it becomes calc-alkalic. Island arcs mark regions where differentiation is taking place at depth and sialic material is rising from the mantle to the surface. This process leads to crustal thickening and abruptly changes the petrochemistry and whole character of volcanism. Volcanism is not a purely surface or intracrustal process, but represents the surface expression of primary subcrustal processes that govern the whole course of the earth's evolution. The formation of island arcs is one of the most important steps in the process. — D. B. V.

- 187-257. Lyustikh, Ye. N. Gipoteza differentsiatsii zemnoy obolochki i geotektonicheskiye obobshcheniya [Hypothesis of differentiation of

the mantle and geotectonic generalizations (with English abstract)): Sovetskaya Geologiya, no. 6, p. 28-52, 1961.

The main factor accounting for vertical movements in geosynclinal belts is interpreted as density inversion, a phenomenon wherein a flexible heavier layer is supported by a fluid lighter one. During the first half of an orogenic cycle, tension in the crust due to thermal expansion of the earth leads to formation of a deep fracture and to downwarping of a geosyncline above this fracture. Granitic magma then flows out of the mantle along the deep fracture and ascends toward the crust or granitic layer. As a result during the second half of the cycle mountains form at the site of the geosyncline, and density inversions control regional and local movements. — J. W. C.

- 187-258. Wang, Kuang-Yen. Problems of the mechanical energy in earth's crust movement [in Chinese]: Ti Chih Lun P'ing [Geological Review], v. 18, no. 1, p. 69-73, 1958.

The thermodynamics and compressive forces involved with cooling of magmas, and the types of forces generated by rotation of the earth are discussed. — J. W. C.

- 187-259. Yen, Tung-Lu. On the fundamental properties of earth's crust movement [in Chinese]: Ti Chih Lun P'ing [Geological Review], v. 18, no. 1, p. 57-68, 1958.

The causes of earth movements and of the evolution of geosynclines into mountains are discussed. — J. W. C.

- 187-260. Markov, K. K. Mouvements glacioisostatiques de l'écorce terrestre [Glacioisostatic movements of the earth's crust, in Symposium on Antarctic Geology (with English summary)]: Internat. Assoc. Sci. Hydrology, Pub. no. 55, (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960), p. 24-28, 1961.

There are two proofs of the magnitude of glacioisostatic movements of the earth's surface. (1) Comparison of the mean altitude (2,350 m) with gravimetric data shows that Antarctica is in isostatic equilibrium; the continent, twice as high as other continents before glaciation, has been depressed under the ice load while maintaining a bedrock altitude close to the mean altitude of the other continents. (2) Comparison of Pleistocene shorelines shows that deformation of the Baltic shield has been 25-50 times greater than that of the relatively stable Caspian area; this difference can be explained only by vertical movement activated by the removal of the ice. — D. B. V.

- 187-261. Vening Meinesz, F. A. Orogeny in the New Guinea, Palao, Halmahera area; geophysical conclusions: Koninkl. Nederlandse Akad. Wetensch. Proc., ser. B, v. 64, no. 2, p. 240-244, 1961.

A recent expedition to New Guinea found that the high mountain range of that island is not essentially folded, as believed, but is a huge block that was overthrust from the north with some eastward displacement. An azimuth of N. 45° W. is calculated for the direction of uniaxial stress that caused the crustal shear. The deforming stress is believed to be due to drag on the crust by a mantle convection current rising under Asia. Below the western half of the Indonesian Archipelago the direction of this current must be about N. 160° E., gradually changing toward N. 150° E. below the eastern half. In the New Guinea area the current should diverge to about N. 135° E. A drag

direction of N. 135° E. compares favorably with the results of soundings in the ocean between Waigeo and the Helen-Tobi Islands, where two parallel ridges were found. If the first ridge is the middle part of an island arc, as suggested by an earlier gravity profile (1929), then the second is the accompanying volcanic arc, inside it with respect to the border of the Asiatic continent. Both arcs probably belong to the Marianas-Bonin system. Deformation in the Bismarck Archipelago fits well with this concept.

There appears to be no current radiating from the Australian continent; if there is one it is completely dominated by the Asiatic current, which continues under Australia via Indonesia and the Philippines and plays the principal part in fashioning the tectonic features of Australia. The difference in relative strength of the currents originating below Australia and Asia may be due to the difference in their size, or to the fact that whereas Asia is part of the ur-continent, Australia now occupies a different location with respect to the mantle and there has not been time for heat to accumulate beneath it. — D. B. V.

- 187-262. Ahmad, R. A brief comparative study of the geological formations of western Australia and peninsular India and its bearing on the drift hypothesis: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 621-636, 1960.

The geologic formations on the west coast of Australia and on the east coast of peninsular India are compared, and it is shown that although information is meager wherever it is reliable close parallels are found between the two areas from Archean to Cretaceous time. These similarities are in rock types, mineral occurrences, climate and glaciation, structure, and fauna and flora. The late Precambrian and the Permian glaciations are cited as examples of similarities that cannot be explained unless drift has taken place. The well known reconstructions of Gondwanaland are discussed, and it is concluded that none is totally satisfactory. Carey's 1951 attempt may be a close approach; the major Cretaceous faulting on this assembly is significant in that all faults from western Australia into India appear to run into one another and then into the Baluchistan orocline. It is concluded that in any future Gondwanaland assembly India and Australia should be regarded as inseparables. India should slide further "southward" than is shown in the 1951 assembly, east Australia should fit close to south Africa, and, if necessary, Ceylon shifted to the west of India. — V. S. N.

- 187-263. Ahmad, F. Glaciation and Gondwanaland: *India Geol. Survey Recs.*, v. 86, pt. 4, p. 637-674, 1960.

The records of glaciation in Gondwanaland from the earliest known to the Tertiary are reviewed. Available faunal and floral evidence does not support the generally held opinion that glaciation was contemporaneous over the whole globe or even in one hemisphere, nor is there evidence that refrigeration occurred at a regular interval. Evidence does suggest that glaciation shifted from one continent to another, and the known features can be explained only if the continents were closer together at that time. The known glacial records from Devonian to Triassic time are placed on a reconstruction of Gondwanaland by Carey, and it is demonstrated that glaciation was undoubtedly continuous throughout this long period. The preservation of the glacial record is the result of negative epeirogeny and drift. It is possible that the drifting of the two continents, Laurasia and Gondwanaland, occasionally brought them closer together and resulted in a cosmopolitan flora and fauna. — V. S. N.

- 187-264. Havemann, Hans. Polwanderung und Epeirophorese als Faktoren des Erdevolution [Polar wandering and epeirophoresis as factors

in the earth's evolution (with English and Russian summaries)]: *Geologie*, v. 10, no. 2, p. 185-213, 1961.

The problem of the origin of the present oceans, continental drift toward the Pacific, and polar wandering is reviewed. There can hardly be any doubt that both epeirophoresis (continental drift) of the southern continents and rather large polar wandering took place during the Mesozoic, preceded by similar but smaller movements in the Paleozoic. Polar wandering and continental drift have a common origin—convection currents in the mantle—and take place simultaneously. A two-page bibliography is given. — D. B. V.

Vacquier, Victor, Duff, Arthur D., and Warren, Robert E. Horizontal displacements in the floor of the northeastern Pacific Ocean. See *Geophys. Abs.* 187-515.

187-265. Mooser, F., and Maldonado-Koerdell, M. Tectonica penecontemporanea a lo largo de la costa Mexicana de Oceano Pacifico [Pene-contemporaneous tectonics along the Mexican Pacific Ocean coast [in Spanish and English]: *Geofísica Internat.*, v. 1, no. 1, p. 3-20, 1961.

Mexico's southern and western portions were subjected during Tertiary time to the formation of several large arches by deep-seated subcrustal forces; onset of volcanism released the pressure and led to collapse of the centers causing the zones to expand into increasingly broad fracture zones that now reflect the slightest surface movement. The dominant crustal pressure now exerted in Mexico comes from the northeast and is causing the gradual encroachment of the continental mass over the Pacific basin in a southwestern direction. The San Andreas fault system, the San Andreas-Chapala line, and the Clarion fracture zone with its continental prolongation are now yielding to lateral stresses of the same tectonic force and producing transcurrent movements. The individual rotations of the different fracture zones exhibit a pattern of movement that is conformable with similar patterns postulated for the whole of North America. — V. S. N.

187-266. Okada, Atsushi. Land deformation of the southern part of the Kii Peninsula, southwestern Japan [in Japanese with English summary]: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 1, p. 113-124, 1960.

Recent deformation in the southern part of the Kii Peninsula was investigated by comparing the results of a precise leveling resurvey with mean sea level variations. Ground tilt along a straight line from Uragami to Kushimoto is shown in a graph. There appears to have been southwesterly tilt, representing continuous subsidence of the southern part of the peninsula in recent years. — D. B. V.

GLACIERS

187-267. Shumskiy, P. A. On the theory of glacier motion: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 142-149, 1961.

Existing dynamic theories of glacier motion are all based on calculation of laminar flow and fail to take into account the most important type of move-

ment, block sliding along the bed or along bottom thrust faults. The calculation of uniaxial longitudinal stresses and deformations, supplemented by the calculation of laminar flow, should serve as a first approximation of glacier motion.

Solutions are given for the moving force in a glacier of arbitrary shape under conditions of a plane problem, for normal and tangential stresses, for rates of ice deformation, and for average velocity.

From these solutions it is possible to determine friction against a glacier bed from measurements of its shape and movement. Dependence of equilibrium shape and dimensions of a stationary glacier on rates of accumulation and ablation, bedrock relief, and external friction is more complicated than in previous theories. With the proposed theory, the values of run-off and spreading, stresses, deformations, and movement can be established separately, so that the role of relief and climate in glacier dynamics can be analyzed. — D. B. V.

- 187-268. Shumskiy, P. A. The dynamics and morphology of glaciers: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 152-161, 1961.

This paper is devoted to analysis of certain relationships between the conditions of existence of glaciers and their dynamics and morphology, on the basis of Shumskiy's proposed theory (see Geophys. Abs. 187-267). A differential equation of the state of a glacier is given; then friction against the bed, inclination of the surface, the steady state of a glacier, the role of subglacial relief and climate in glacier dynamics, a morphologic-dynamic classification of glaciers (run-off, mountain-sheet, sheet, and out-flow), intensity of geologic activity of glaciers, and the evolution of glaciers are discussed. — D. B. V.

- 187-269. Weertman, J. Stability of ice-age ice sheets: Jour. Geophys. Research, v. 66, no. 11, p. 3783-3792, 1961.

Application of the present-day theory of ice flow in glaciers and ice sheets leads to the conclusion that a small Arctic icecap can become unstable and expand into a large ice age sheet as a result of moderate changes in the regime of the icecap, and that a large continental ice sheet can become unstable and disappear if snow accumulation is reduced or the ablation rate increased. The results fit well with the Ewing-Donn theory of ice ages. — D. B. V.

- 187-270. Haefeli, R[obert]. Contribution to the movement and the form of ice sheets in the Arctic and Antarctic: Jour. Glaciology, v. 3, no. 30, p. 1133-1151, 1961.

Starting from Glen's flow law for ice and from a series of assumptions based in part on observations in Greenland and in the Jungfrauoch, the velocity distribution (horizontal velocity component) and surface configuration is derived for a strip-shaped ice sheet in a stationary state. For the choice $n=3-4$ of the exponent in the power-law flow relation, there is extensive agreement between the theoretically calculated surface profile and the east-west profile measured through "Station Centrale" by Expéditions Polaires Françaises. The corresponding theoretical solution for a circular ice sheet is also given. As a first application of this theory, an attempt is made to calculate the average rate of accumulation in Antarctica from its surface profile (assumed circular in plan) and from the flow-law parameters derived from the Greenland Ice Sheet. It is also shown that a change in accumulation has only a small influence on the

total ice thickness of an ice sheet. A method of calculating approximately the age of ice in an ice sheet, based on the foregoing theory, is illustrated by applying it to the Greenland Ice Sheet. After comparing the present theory with that of Nye, a general expression for the surface profile of an ice sheet with constant accumulation is set up and discussed by means of comparison with two profiles through Antarctica. — Author's abstract

- 187-271. Haefeli, R[obert]. Eine Parallele zwischen der Eiskalotte Jungfrauoch und der Eisschildern der Arktis und Antarktis [A parallel between the icecap of the Jungfrauoch and the inland ice of the Arctic and Antarctic]: *Geologie u. Bauwesen*, v. 26, no. 4, p. 191-213, 1961.

Continual measurements were made inside an ice tunnel during the period 1950-60 in the icecap of the Jungfrauoch. This icecap can be considered in many ways to be a scale model of a large ice sheet. The experience from its study and that from the French Greenland expedition are a basis for developing a theory of the steady state motion of ice sheets within the firn region where simple assumptions are made as to the general validity for the flow law of polycrystalline ice in a more or less horizontal bed on which the ice is fixed (no sliding). The parameters of the ice are determined in such a way that the difference between the calculated surface profile on the central part of the Greenland ice sheet and the profile measured by the French expedition becomes insignificant. Thus, the steady motion of an ice sheet in equilibrium can be considered as a state of continuous creep under the influence of only gravity (see also *Geophys. Abs.* 187-270). — J. W. C.

- 187-272. Glen, J. W., and Lewis, W. V. Measurements of slide-slip at Austerdalsbreen, 1959: *Jour. Glaciology*, v. 3, no. 30, p. 1109-1122, 1961.

Measurements of the rate at which Austerdalsbreen Glacier is slipping past its side wall were made at four different sites. The rate is less than the slip previously measured up-glacier at the foot of an icefall, and is also about one-sixth the rate found in the center of the glacier. Velocities of the last meter of ice are more erratic than those a few meters from the edge. This suggests that protuberances of rock and boulders between the ice and rock wall cause local variations in flow which smooth out within a few meters. The results are discussed in connection with the process of glacial erosion. — V. S. N.

- 187-273. Carter, Adams, and Atherton, David. Milton Mt. McKinley Range expedition, 1960: *Jour. Glaciology*, v. 3, no. 30, p. 1123-1132, 1961.

Results of a reconnaissance expedition during the summer of 1958 on the north fork of the Eldridge Glacier, Mount McKinley National Park, Alaska, are reported. Velocity profiles were made to determine the type of glacier flow; the movement to width ratio is high (1:6) and thus Block-Schollen type of movement is likely. The velocity profiles also show both slip at the glacier's edge and shear in the adjacent layers. It is concluded that glaciers in this region are near their recent maximum because the high altitude accumulation offsets the shrinking of the lower tributary glaciers. — V. S. N.

- 187-274. Cameron, R. L., and Goldthwait, R. P. The US-IGY contribution to Antarctic glaciology: *Internat. Assoc. Sci. Hydrology Pub.*, no. 55 (*Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology*), p. 7-13, 1961.

A snow accumulation map of Antarctica is presented, compiled from data from Little America, Marie Byrd, South Pole, and Wilkes stations as well as data collected by other countries. The largest accumulation is on the east side of the Weddell Sea, the smallest in the vicinity of the Pole of Inaccessibility. A map of mean annual air temperature shows that the "cold pole" (-57°C to -59°C) lies near Vostok II Station.

Relative motion networks showed that there was no appreciable glacier expansion in 1958-59. Measurements of absolute movement show that the glaciers along the coast of east Antarctica may be discharging ice faster than previously postulated; Vanderford Glacier moves 2.1 m per day, whereas Skelton Glacier moves into the Ross Ice Shelf at a rate of 0.28 m per day. — D. B. V

- 187-275. Yevteyev, S. A. The geological activity of the ice cover in eastern Antarctica: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 14-17, 1961.

In the area studied by the Soviet Antarctic Expedition (long 78° - 110° E.) the icecap reaches a thickness of 3,000 m and, flowing at a rate of nearly 1,000 m per yr in its most mobile parts, exerts an intensive effect on the underlying bedrock. The thickness of the moraine-bearing layer at the base of the ice sheet reaches 100 m in the fast-flowing glacial currents and varies between 10 and 40 m in slower-moving parts. A combination of mechanisms within the moraine-bearing ice (visco-plastic flow and gliding along internal shear surfaces) causes boulders in the debris to become oriented lengthwise in the direction of movement, and erratics to acquire a "flatiron" shape. It is calculated that about 0.05 mm is removed annually from the bedrock surface of east Antarctica; this is comparable to stream erosion in plains regions. — D. B. V.

- 187-276. Bauer, A. Nouvelle estimation du volume de la glace de l'inlandsis antarctique [New estimate of the volume of ice in the Antarctic icecap]: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 19-23, 1961.

On the basis of International Geophysical Year data, the volume of the Antarctic icecap is calculated to be $33 \times 10^7 \text{ km}^3$. — D. B. V.

- 187-277. McLeod, I. R., and Jesson, E. E. Inland ice movement in MacRobertson Land, Antarctica: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 57-62, 1961.

Details are given of the ice thickness and surface velocity measurements along an east-west line 12 km inland from the coast of MacRobertson Land. Approximately $68 \times 10^5 \text{ kg}$ of water equivalent of ice flows across each meter of this line annually, and $38 \times 10^5 \text{ kg}$ of water equivalent of ice reaches each meter of this part of the coastline each year. — Authors' abstract

- 187-278. Bender, J. A., and Gow, A. J. Deep drilling in Antarctica: Internat. Assoc. Sci. Hydrology Pub., no. 55 (Internat. Union Geodesy and Geophysics, Gen. Assembly, Helsinki 1960, Symposium on Antarctic Geology), p. 132-141, 1961.

Using a modified rotary well drilling rig with compressed air as the drilling fluid, excellent cores were obtained down to 308 m at Byrd Station and down to 254 m on shelf ice at Little America. Detailed analysis of the cores indicates an annual accumulation of 15 and 21 cm of water equivalent at these two stations, respectively. Depth-density and depth-temperature curves are given. Continuation of measurements at the Byrd Station hole indicates that in 2 years there was no change in temperature with depth or in inclination, and that the hole was closing very rapidly with depth and nonlinearly with time. — D. B. V.

- 187-279. Stuart, A. W., and Heine, A. J. Glaciological work of the 1959-60 U. S. Victoria Land traverse: *Jour. Glaciology*, v. 3, no. 30, p. 997-1002, 1961.

Observations were made of snow accumulation, sastrugi, as indicators of wind direction, and movement of the Ross Ice Shelf as a part of a seismic-glaciological reconnaissance of Victoria Land, Antarctica, from October 1959 to February 1960. Movement and accumulation data were determined from remeasurement of stakes emplaced by a previous traverse. Movement points on the Ross Ice Shelf show a maximum rate of about 844 m per yr with lesser rates in the more marginal areas. — V. S. N.

- 187-280. Crary, A. P., and Wilson, Charles R. Formation of "blue" glacier ice by horizontal compressive forces: *Jour. Glaciology*, v. 3, no. 30, p. 1045-1050, 1961.

Data are supplied to show that the "blue" ice area with high surface densities encountered in the Skelton Glacier, Antarctica, results from horizontal compressive forces and the absence of accumulation due to strong katabatic winds. Examples of the densification of surface snows of the Ross Ice Shelf by this means are also given. Such density changes should be expected in any area where either of the principal horizontal strain-rates is negative. — V. S. N.

- 187-281. Wexler, H. Growth and thermal structure of the deep ice in Byrd Land, Antarctica: *Jour. Glaciology*, v. 3, no. 30, p. 1075-1087, 1961.

Times of growth of the ice shelf in the channel connecting the Ross and Bellingshausen Seas by combined freezing from below and accumulation above at the rate of 10 and 20 cm per yr, respectively, are determined for the case of a linear temperature profile in the ice. After the ice shelf becomes grounded, further growth is by accumulation only. Steady-state temperature profiles for ice sheets 2,300 and 4,300 m thick are computed under assumption of a constant geothermal heat flux of 10^{-6} cal cm⁻²sec⁻¹ and compared with observed temperatures in the 300 m drill hole at Byrd Station (see *Geophys. Abs.* 177-185). The effect of down-slope motion and sinking of ice strata on the vertical temperature profile of the surface layer is studied with aid of the Benfield-Radok formula. Assuming no climatic temperature change and an initial temperature gradient at the ice crest 1°C increase per 100 m increase in depth, the curve of best fit of all those tried is for a sinking rate of 20 cm per yr and a down-slope speed of 85 m per yr. Calculations are given to show that for the thickness of 4,300 m found 200 km east of Byrd Station a total of 40,390 and 20,720 yr of accumulation at the rates of 10 and 20 cm per yr, respectively, are required. — V. S. N.

- Kamb, W. Barclay. The glide direction in ice. See *Geophys. Abs.* 187-598.

Krausz, A. S. Etching technique to study plastic deformation of ice. See *Geophys. Abs.* 187-597.

GRAVITY

- 187-282. Newton, R. R., Hopfield, H. S., and Kline, R. C. Odd harmonics in the earth's gravitational field: *Nature*, v. 190, no. 4776, p. 617-618, 1961.

The odd harmonics J_3 , J_5 , and J_7 of the earth's gravitational field are calculated from satellite data (1958 β , 1960 γ , and 1960 η) as $(-2.36 \pm 0.14) \times 10^{-6}$, $(-0.19 \pm 0.10) \times 10^{-6}$, and $(-0.28 \pm 0.11) \times 10^{-6}$, respectively. It is interesting that the value of J_7 obtained here is larger than that of J_5 , although the difference is less than the probable error. It may be that the values of the harmonics beginning with the fifth will be determined principally by the topography and will thus tend to decrease slowly but erratically with increasing order. — D. B. V.

- 187-283. Kozai, Yoshihide. The gravitational field of the earth derived from motions of three satellites: *Astron. Jour.*, v. 66, no. 1, p. 8-10, 1961.

Coefficients of the second, third, fourth, and fifth harmonics of the gravitational field of the earth are determined from analysis of motions of the satellites 1958 β 2 (Vanguard I), 1959 η (Vanguard III), and 1959 ϵ 1 (Explorer VII) to be: $A_2/a_e^2 = (1.62329 \pm 0.00004) \times 10^{-3}$, $A_3/a_e^3 = (2.29 \pm 0.02) \times 10^{-6}$, $A_4/a_e^4 = (9.3 \pm 0.2) \times 10^{-6}$, and $A_5/a_e^5 = (2.3 \pm 0.2) \times 10^{-7}$. — D. B. V.

- 187-284. Kozai, Yoshihide. The motion of a close earth satellite: *Astron. Jour.*, v. 64, no. 9, p. 367-377, 1959.

Perturbations of six orbital elements of a close earth satellite moving in the gravitational field of the earth without air-resistance are derived as functions of mean orbital elements and time. It is assumed that the density distribution of the earth is symmetrical with respect to the axis of rotation, that the coefficient of the second harmonic of the potential is a small quantity of the first order, and that the coefficients of the third and fourth harmonics are of the second order. It is shown that there are no long-periodic terms of the first order in the expression of the semimajor axis. — D. B. V.

- 187-285. Kozai, Yoshihide. Potential field of the earth derived from motions of artificial satellites, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 174-176, 1961.

The advantages of the satellite-tracking method of determining the coefficients of the zonal harmonics of the earth's gravitational field are outlined, and present and future accuracy of the method is discussed. — D. B. V.

- 187-286. Lambert, Walter [D.]. The gravity field of an ellipsoid of revolution as a level surface: *Acad. Sci. Fennicae Annales*, ser. A-III, no. 57, 42 p., 1961; reprinted as Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 14, 1961.

The reference ellipsoid on which the official gravity formula is based may differ somewhat from the best-fitting ellipsoid without detracting from the ul-

timely accuracy of conclusions from gravimetric data, because the geoid is the same geoid even though the reference surface may change. There are two methods of determining the gravity field of the reference ellipsoid. The method using curvilinear coordinates, not yet found in standard treatises on geodesy, is summarized and developed here both for its own sake and for comparison purposes.

The second method is based on the fact that the figure of equilibrium for a homogeneous earth is an exact ellipsoid; by assuming a thin "coating" of high negative density, a perfectly general expression can be found for the potential and for the components of gravitational attraction or of gravity in terms of powers of $1/r$ (r =radius vector) multiplied by the appropriate zonal harmonics. Both methods yield the same closed formula for gravity on the surface of the ellipsoid and equivalent formulas for outer space. The second is much simpler mathematically.

The two main parts of this paper are mathematical treatments of the special ellipsoidal coordinates and their properties, and of gravity and gravitational attraction in terms of ordinary spherical coordinates. — D. B. V.

- 187-287. Parasnis, D. S. Exact expressions for the gravitational attraction of a circular lamina at all points of space and of a right circular vertical cylinder at points external to it: *Geophys. Prosp.*, v. 9, no. 3, p. 382-398, 1961.

The gravitational attraction of a circular lamina and a right circular vertical cylinder at any axial point can be found by elementary methods. The usual method of estimating the attraction at a point P off the axis is valid only if P is a distant point. As a step towards calculating exactly the attraction of the cylinder at all points of the space external to it, the corresponding problem for the lamina is treated first. It is shown that the anomaly can be expressed as an infinite series in even powers of the horizontal distance P . The coefficients of the powers consist of exact algebraic expressions containing simple terms of the form $(1+x^2)^{-n-1/2}$. These coefficients are determined by exactly summing certain infinite series involving the derivatives of the Legendre polynomials of odd order. The method of summation is believed to be of interest also in other problems where Legendre polynomials are encountered. The attraction of the cylinder is calculated by approximately integrating the expression for the attraction of the lamina.

Numerical calculations show that the approximate method everywhere underestimates the gravity anomaly of the lamina as well as that of the cylinder. The error at distances one or two times the radius is up to 20 percent for the lamina and 8.5 percent for an infinitely long cylinder. — D. B. V.

- 187-288. Andreyev, B. A. Gravitatsionnyye anomalii Faya i izostaziya [Faye gravity anomalies and isostasy]: *Akad. Nauk SSSR Doklady*, v. 139, no. 1, p. 91-93, 1961.

The difference between the Faye anomaly (Δg_F) and the isostatic anomaly (Δg_I) is investigated and found to depend closely on h (altitude of the observation point, if on a continent, or depth to bottom, if at sea). The relationship appears to be linear for continental stations with $h > 1.3$ km and for all oceanic stations; $\Delta g_F - \Delta g_I$ increases with altitude and decreases with depth. The maximum positive average values of $\Delta g_F - \Delta g_I$ are observed when altitude is maximum (up to 275 mgal for $h = +4$ km) and the lowest negative values when ocean depth is maximum (to -130 mgal for $h = -8$ km). For almost all continental stations between 0 and 1.3 km high, $\Delta g_F - \Delta g_I$ has small negative values.

For regions in which the height of the relief varies in a relatively narrow interval, it should be possible to predict the mean value of $\Delta g_F - \Delta g_I$, or knowing Δg_F , to predict Δg_I . As an example, the isostatic anomaly for central East Antarctica is calculated as -80 mgal. — D. B. V.

- 187-289. Troshkov, G. A., and Shalayev, S. V. *Primeneniye preobrazovaniya Fur'ye dlya resheniya obratnoy zadachi gravirazvedki i magnitorazvedki* [Application of Fourier transformation to solutions of the inverse problem of gravity and magnetic prospecting]: *Prikladnaya Geofizika*, no. 30, p. 162-178, 1961.

A pair of Fourier transformations, $f(x) = (1/2\pi) \int_{-\infty}^{+\infty} S(\omega) e^{-i\omega x} d\omega$, and $S(\omega) = \int_{-\infty}^{+\infty} f(x) e^{i\omega x} dx$ are applied to the problem of determination of the attitude of elements of geologic bodies producing gravity and magnetic anomalies. In the above equations $f(x)$ is a real or complex function that satisfies the conditions of convergence of the integrals; $S(\omega)$ is the Fourier transformation of the function $f(x)$, and ω is a certain real variable. The method is developed and expressions obtained for transformations of $S(\omega)$ for two-dimensional bodies whose vertical cross sections are bounded by an arbitrary broken line of a finite number of links. The method yielded a depth of 800 m to a disturbing body, which was determined by a borehole to be at 750 m. — A. J. S.

- 187-290. Lukavchenko, P. I. *O geologorazvedochnom znachenii tret'ey proizvodnoy potentsiala silytyazhesti* [On the geological prospecting significance of the third derivative of gravity potential]: *Prikladnaya Geofizika*, no. 30, p. 115-142, 1961.

An evaluation of applicability to geological prospecting and methods of calculation of the third derivatives U_{zzx} and U_{zzy} of gravity potential is given. Procedures are demonstrated for calculating averaged gravity anomalies at the surface for bodies of known simple geometry (sphere, horizontal infinite circular cylinder, vertical bench, horizontal half-plane, thin vertical cylinder, thin infinite layer, horizontal layer of infinite extension, and thin vertical layer of limited downward extent), and for determination of their elements of attitude according to characteristic points of the anomaly curves. The methods of U_{zzx} and U_{zzy} calculation for two- and three-dimensional cases are given, and preparation of master charts of the derivatives for a given value of Z is worked out. The Kilchling torsional gravimeter (see *Geophys. Abs.* 170-181) is suggested for direct measurement of the derivatives. The accuracy of the balance is 1×10^{-12} cgs, its moment of inertia—4,760 cgs, oscillation period—15 m20s, and damping period—3 hr. A diagram of the gravimeter is given. — A. J. S.

- 187-291. Yun'kov, A. A. *Obchyslennyya anomalii V_{xz} nad tryvymirnymy tilami paletkoyu dvovymirnogo tila* [Calculation of anomalies V_{xz} of three-dimensional bodies with a master chart for a two-dimensional body]: *Akad. Nauk Ukrayin. RSR Dopovid*, no. 9, p. 1224-1226, 1960.

A new method of interpretation of anomalies of V_{xz} produced by three-dimensional bodies of arbitrary geometry by using a single master chart for a two-dimensional body is proposed, and a mathematical analysis of the method is presented. — A. J. S.

- 187-292. Yun'kov, A. A. Obchyslennya anomaliiy V_{Δ} nad tryvymyrmnymytilami paletkoyu dvovymyrmnogo tila [Calculation of anomalies V_{Δ} of three-dimensional bodies with a master chart for a two-dimensional body]: Akad. Nauk Ukrayin. RSR Dopovidī, no. 10, p. 1393-1395, 1960.

The same method as in Yun'kov's preceding paper (see Geophys. Abs. 187-291) is discussed and analyzed mathematically for determination of the potential anomaly V_{Δ} . — A. J. S.

- 187-293. Kartevilishvili, K. M. Kriterii dlya proverki interpretatsii gravitatsionnoy anomalii V_{zz} . [Critical for verification of a V_{zz} gravity anomaly]: Akad. Nauk Gruzin. SSR Soobshch., v. 25, no. 6, p. 655-658, 1960.

This is a mathematical analysis of the second vertical derivative of gravity potential $V_{zz} = g^2 v / a z^2$. Criteria for quantitative interpretation of V_{zz} gravity anomalies are developed for two- and three-dimensional disturbing bodies. — A. J. S.

- 187-294. Paul, M. K. On computation of the second derivatives from gravity data: Geofisica Pura e Appl., v. 48, p. 7-15, 1961.

Second derivative formulas of Elkins and Rosenbach (see Geophys. Abs. 144-12620, 155-14811, respectively) are developed from a unified approach, and their merits and demerits are discussed. Some new formulas are presented that theoretically should prove more efficient. — D. B. V.

Morgan, W. J., Stoner, J. O., and Dicke, R. H. Periodicity of earthquakes and the invariance of the gravitational constant. See Geophys. Abs. 187-101.

- 187-295. Tengström, Erik. An approximate method for calculating the depth of a surface-reaching gravitational mass-anomaly, giving a Bouguer-field with radial or axial symmetry: Geofisica Pura e Appl., v. 46, p. 23-25, 1960.

A method for determining the size and shape of a disturbing body in gravity surveying is described. The problem is treated as a surface-reaching vertical cylinder (when the local Bouguer anomaly has radial symmetry) or as an infinite parallelepiped (when the local Bouguer anomaly has axial symmetry). An expression for M_0 is given that serves to distinguish easily between deep-seated and shallow disturbances. — D. B. V.

- 187-296. Avdulov, M. V. Ob interpretatsii gravitatsionnykh i magnitnykh nablyudeniy metodom teoreticheskikh poley [On interpretation of gravity and magnetic observations by the method of theoretical fields]: Prikladnaya Geofizika, no. 30, p. 143-153, 1961.

The method of interpretation of gravity and magnetic observational data by comparing theoretical curves of anomalies due to bodies of a regular geometrical shape with the curves obtained by observation is discussed. Formulas for the transformation of gravity anomalies into anomalies of their vertical gradient, and for the second derivatives of these gradients are given for a vertical circular cylinder, a horizontal cylindrical segment, a vertical elliptical segment, a horizontal elliptical cylinder, an extended anticline limited by planes, and a body of vertical cross section in the form of a parallel-

ogram inclined at an angle α . Similar calculations for a spheroid of revolution, a parallelepiped, a hyperbolic cupola, and fault scarps are suggested. The preparation of bilogarithmic master charts is considered for a sphere, half-sphere, and a vertical material line. — A. J. S.

- 187-297. Tushkanov, L. Ya. Interpretatsiya gravitatsionnykh anomalii dlya tel peremennoy plotnosti [Interpretation of gravity anomalies for bodies of variable density]: Prikladnaya Geofizika, no. 30, p. 154-161, 1961.

The method of interpretation of gravity anomalies due to salt dome tectonics in the Emba region is discussed. Circular master charts have been designed for the peripheral slopes of the domes and for the zones between the domes. — A. J. S.

- 187-298. Shvank, O. A. Osobennosti razlichnykh proizvodnykh sily tyazhesti v svyazi s interpretatsiy gravimetricheskikh nablyudeniy [Features of various gravity derivatives with regard to interpretation of gravimetric observations]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 55-61, 1960.

Tables are given of the first, second, and third derivatives of gravity anomalies over a sphere, horizontal cylinder, and horizontal half-plane expressed in 10^{-9} cgs units as the functions of the coordinate x . For a similar body with coordinate dimensions increased by a factor n , so that $x_n = nx$, $y_n = ny$, and $z_n = nz$, the tabular values of the first, second, and third derivatives can be obtained by multiplying x and the first derivative by n , the third derivative by $1/n$, and leaving the second derivative values unchanged. The first anomaly derivatives can be used in investigations of regional structures, and the second and especially the third anomaly derivatives can be found useful in investigations of local structures. — A. J. S.

Halushko [Galushko], P. Ya. On the possibility of studying vertical movements of the earth's crust by means of gravity anomalies. See Geophys. Abs. 187-250.

- 187-299. LaCoste, L. J. B., and Harrison, J[ohn] C. Some theoretical considerations in the measurement of gravity at sea: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 89-101, 1961.

The theory of operation of spring gravimeters on a stabilized platform in the presence of horizontal and vertical accelerations is considered in the first section of the paper. It is shown that leveling errors with the same period as the horizontal accelerations are very important; their amplitude should not exceed about 8 sec of arc when the amplitude of the horizontal accelerations is 50,000 mgal. A second effect, called the "cross-coupling" effect, is present even on a perfectly stabilized platform; it is produced by coupling between the vertical and horizontal accelerations and may cause an error of more than 100 mgal when horizontal and vertical accelerations both have amplitudes of 50,000 mgal. The second part of the paper discusses a gravimeter free to swing in gimbals. An expression for the second-order correction is derived, taking into account free and forced oscillations of the gimbal system. When the gravity sensing element is positioned at the correct distance below the gimbal axis, this expression takes the simple form $1/2 g \bar{\theta}^2$ ($\bar{\theta}$ = deflection of the gimbal system from true vertical). — D. B. V.

- 187-300. Paterson, Norman R. New methods of elevation control speed reconnaissance gravity surveys in northern areas: Canadian Inst. Mining and Metallurgy Trans., v. 63, p. 407-415, 1960.

Under certain conditions useful gravity information of a reconnaissance nature can be obtained without measuring elevations by spirit level surveys on the ground. The new procedures are most applicable to remote areas, areas where ground transportation is slow and difficult, and areas where station spacing is large in comparison with the distance of the average optimum level shot. Transportation by helicopter or light plane is usually necessary. The methods discussed are the photogrammetric-Airborne Profile Recorder (APR) spot determinations; barometric altimeter surveys; and the measurement of gravity gradients. Test surveys are described and their accuracy compared with that of level surveys. It is concluded that the three methods have particular application to exploration in northern Canada. The barometric altimeter is serving an increasingly useful role in gravity surveys for iron and for regional geological mapping; similar techniques can be valuable in petroleum exploration in the north. — V. S. N.

- 187-301. Steiner, Franz. Zur Frage der Dichtbestimmung an gravimetrisches Profilmessungen [On the problem of density determination in gravimetric profile measurements (with English abstract)]: Gerlands Beitr. Geophysik, v. 70, no. 1, p. 11-17, 1961.

A simpler but even more accurate transformation than Jung's (see Geophys. Abs. 181-253) transformation of a surface method of gravimetric determination of mean density for profile measurements is presented. — D. B. V.

- 187-302. Slepak, Z. M. Ob opredelenii plotnosti porod pri gravimetricheskoy razvedke [On determination of density of rocks in connection with gravity surveying]: Geologiya Nefti i Gaza, no. 8, p. 48-49, 1959.

A method is presented for gravity profiling that takes into account the density of the rocks of the intermediate layer. Measurements are made at 5-7 points on a profile 500-1,500 m in length. Gravity anomalies are calculated along this profile for various values of density of the rocks of the intermediate layer, and the values of these anomalies are plotted on a graph. The resulting curve that is closest to a straight line is the most reliable value of the density. — J. W. C.

- 187-303. Durbin, William P., Jr. Some correlations of gravity and geology (with discussion), in Geodesy in the space age (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 130-137, 1961.

The demand for worldwide gravity coverage has led to the necessity for a quick method of determining an anomaly from physical evidence, as well as for a more accurate method of assigning substitute values to unsurveyed areas. The correlation of gravity with geologic structures and formations is being investigated in a new approach by attempting to establish procedures whereby the gravity anomaly for any area may be easily computed while maintaining a predictable accuracy. The procedure is discussed, and a gravity map of "geological anomalies" is given for the south central United States. These anomalies were computed wherever a predominant structure was in evidence. Accuracy was evaluated by means of profile and mean anomaly

comparisons. Mutual agreement between the free air, isostatic, and geologic anomaly profiles rarely exceeded 10 mgal, and the Bouguer anomaly profile showed very little, if any, agreement. A possible application of this procedure would be the determination of the degree of isostatic equilibrium for a given area. — D. B. V.

- 187-304. Guha, S. K. A review of gravity method: Jour. Mines, Metals, and Fuels (India), v. 9, no. 7, p. 25-27, 1961.

The principles underlying the gravity method of exploration for oil and the methods of interpretation of results are reviewed. — V. S. N.

Innes, M. J. S. The use of gravity methods to study the underground structure and impact energy of meteorite craters. See Geophys. Abs. 187-74.

- 187-305. Thompson, Lloyd G. D., and Szabo, Bela. The role of the airborne gravity meter in determining the earth's gravity field, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 126-130, 1961.

Geodetic and space navigation requirements can be ideally satisfied by airborne gravity observations because: (1) the observations yield the average effect of anomalies over large areas, (2) properly chosen time (or distance) average readings will represent an average gravity value for a given area on the earth's surface, (3) the observations are made outside the earth's topography, (4) the required navigation accuracy can be achieved with existing equipment, (5) airborne observations are possible over otherwise inaccessible terrain, and (6) the reduction and computation procedures are easier to perform from airborne observations than from ground data.

By proper planning of airborne profiles, adequate coverage of $1^\circ \times 1^\circ$ average values can be obtained to derive the regional and general gravity fields for geodetic requirements; only detailed surveys for specific points should be done by conventional surveys. The $1^\circ \times 1^\circ$ coverage will also permit determination of the geoid with sufficient accuracy for reduction of extensive geodetic surveys such as Hiran from the geoid to the reference ellipsoid. After orbital coverage is complete, the gravity field of the earth can be computed in any form necessary for satellite orbital computations and space navigation.

So far, only the LaCoste-Romberg gravimeter has been extensively tested for airborne use; some changes and improvements should be made to adapt it to use in military aircraft. Airborne use of the Graf sea gravimeter is currently being investigated. — D. B. V.

- 187-306. Heifetz, M. E. A high precision pendulum apparatus: Bull. Géod., no. 60, p. 177-182, 1961.

A new pendulum apparatus designed by the Central Research Institute of Geodesy, Aerial Photographic Survey, and Cartography in the U. S. S. R. for the determination of local gravity base stations is described, and the results of preliminary test measurements at four stations are reported. — D. B. V.

- 187-307. Wolf, H[elmut]. Möglichkeiten für genauere relative Schweremessungen durch Pendel in stationären Anlagen [Possibilities for more accurate relative gravity measurements by means of pendulums in fixed installations]: Bull. Géod., no. 60, p. 183-188, 1961.

It is suggested that the accuracy of relative gravity measurements can be vastly improved by installing fixed pendulums at several points in a gravity

network; Hoffrogge in 1949 achieved an accuracy of 1×10^{-7} with such equipment. The principles and procedure of this type of measurement are outlined. It is shown how the true error and mean error depend on the duration of the observations. — D. B. V.

- 187-308. Uotila, Urho A. [K.]. Existing gravity material, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 91-97, 1961.

The Columbus group has collected gravity data from more than 50 countries and catalogued about 500 publications as sources. This material has been evaluated carefully and all observations have been related to the Potsdam system. Counting all $1^\circ \times 1^\circ$ squares where there is at least one observation, 30.5 percent of the earth is covered; of this, 72 percent is in the northern hemisphere and the distribution is relatively good. The Pacific Ocean is the largest unsurveyed area, with about 50 empty $10^\circ \times 10^\circ$ squares in one continuous block.

Elimination of the largest gaps with a few profiles would considerably improve the accuracy of the orientations of the reference surfaces. Even though this might not reduce the inaccuracies to one half, it may solve other problems of physical geodesy, including the pear-shaped earth and flattening of the equator. — D. B. V.

- 187-309. Woollard, George P[ryor]. The status of gravimetric control for global geodetic studies, in *Geodesy in the space age (symposium)*: Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 97-115, 1961.

As the success of position-fixing schemes such as Loran and Sofar depends entirely on the accurate location of shore control and monitoring stations relative to each other, geodesy, and with it gravimetry, suddenly became important in World War II. The reliability of national gravity base values in use was subjected to critical scrutiny, and in 1948 a program of international gravity control measurements was initiated. The method of evaluating the world gravity base network, the problem of calibration of gravimeters, and the world network of secondary airport bases and its reliability are discussed.

Comparison of results obtained in different parts of the world by different observers shows that the use of an international gravity standard for gravimeter calibration would result in a more unified body of data than is now available. Results consistent to ± 0.3 mgal can now be obtained with gravimeters on a global basis; as this equals the reliability of the best pendulums, there seems to be little reason for a new pendulum network except for extending the range of existing standardization measurements and strengthening the standardization base values already established. By making multiple intercontinental ties involving small changes in gravity with exploration type gravimeters reliable to 0.01 mgal or better, the present global reliability could be improved considerably. Extension of present international cooperation could provide, in the next decade, highly reliable gravity data for all of the earth. — D. B. V.

- 187-310. Kneissl, M[ax]. Das europäische Gravimetereichsystem [The European gravimeter calibration system]: Bull. Géod., no. 60, p. 111-123, 1961.

This is a report on the progress of the European gravimeter calibration network, given before the International Association of Geodesy at Helsinki in 1960. — D. B. V.

- 187-311. Marzahn, K[urt]. Vorbereitung der gemeinsam Ausgleichung der Pendel-und Gravimetermessungen des europäischen Gravimeter-Eichsystems [Preparation of the common adjustment of the pendulum and gravimeter measurements of the European gravimeter calibration system]: Bull. Géod., no. 60, p. 125-130, 1961.

This report discusses the calculation procedures, the choice of the pendulum and gravimeter measurements, and the fundamentals of adjustment used in connection with the European gravimeter calibration network. — D. B. V.

- 187-312. Cook, A[lan] H[ugh]. Report on absolute measurements of gravity: Bull. Géod., no. 60, p. 131-139, 1961.

Some 12 new absolute determinations of gravity had been made since 1946 or were underway at the time of this report, made to the International Association of Geodesy at Helsinki in 1960. Measurements in progress were using either pendulums or the free fall method. Results to date are tabulated. — D. B. V.

- 187-313. Winter, P. J., Valliant, H. D., and Hamilton, A. C. Pendulum observations at Ottawa, Gander, Teddington, Paris, Rome, and Bad Harzburg: Bull. Géod., no. 60, p. 142-166, 1961.

Observed periods, gravity differences, and standard deviations determined by means of pendulum measurements made during the summer of 1959, using the bronze bipendulum apparatus of the Dominion Observatory of Canada, are listed. Stations were occupied sequentially as follows: Ottawa, Gander, Ottawa, Teddington, Bad Harzburg, Rome, Paris, Teddington, and Ottawa.

The following provisional values of absolute gravity relative to the Potsdam system have been computed: Teddington 981.19638, Ottawa 980.62062, Washington 980.09991, Paris 980.93995, and Rome 980.36267 gal. Error does not exceed 0.5 mgal. The apparatus, procedure, sites, computations, consistency of the observations, and network adjustment are described. — D. B. V.

- 187-314. Mazzon, C[ozzad]o. Mesures pendulaires exécutées sur la L. T. E. de Hammerfest à Catane [Pendulum measurements made on the European triangulation network (L. T. E.) from Hammerfest to Catania]: Bull. Géod., no. 60, p. 167-176, 1961.

The results of pendulum measurements made by the Instituto di Geodesia, Topografia e Fotogrammetria of the Milan Polytechnicum from Hammerfest, Norway, to Catania, Sicily, are reported. Gravity values and differences from Potsdam are tabulated for Hammerfest, Bodø, Oslo, Copenhagen, Bad Harzburg, Monaco, Milan, Bologna, Rome, and Catania. Several general conclusions are drawn concerning the execution of modern pendulum measurements. — D. B. V.

- 187-315. Lozano Calvo, Luis. Informe sobre los trabajos de nivelaciones de alta precisión ejecutados por el Instituto Geográfico y Catastral de España en el trienio de 1957-60 [Report on high precision leveling work done by the Instituto Geográfico y Catastral of Spain during the triennium 1957-60]: Madrid, Inst. Geográfico y Catastral, 8 p., 1960.

During the period 1957-60, El Jefe del Servicio de Gravimetria of Spain has accomplished three major works: completion of a fundamental gravity

map for Spain, observation and calculation of a detailed gravity net for the province of Toledo, and collaboration on international projects. The fundamental gravity net for Spain is described, and absolute gravity values for 144 stations are listed in a table. — J. W. C.

- 187-316. Helbig, K[laus], and Thirlaway, H. I. S. New gravity measurements in West Pakistan: Royal Astron. Soc. Geophys. Jour., v. 5, no. 2, p. 171-178, 1961.

A gravity base network of eight air links connected to Woollard's Karachi airport station (adopted value, $g=978,963.0 \text{ cm/s}^2$) has been established in West Pakistan, using a Worden "Master" gravimeter No. 551. A selection of 21 new values based on these air links is reported and the stations are described. The gravity air links relative to the Karachi value are estimated to have a standard deviation of 0.2 mgal or better. Standard deviations based on repeat observations by road and rail transport reach a maximum of 0.3 mgal.

Comparisons between the 12 Survey of India pendulum stations and gravimeter values are graphed. The pendulum observations lie within ± 2 mgal of the new results over a range of 700 mgal. It may be possible to derive a sway correction for the pre-Cambridge pendulum values from the results. — D. B. V.

- 187-317. Dooley, J. C., McCarthy, E., Keating, W. D., Maddern, C. A., and Williams, L. W. Pendulum measurements of gravity in Australia 1950-51: Australia Mineral Resources, Geology and Geophysics Bull., no. 46, 76 p., 1961.

Pendulum gravity observations were made at 59 stations throughout Australia during 1950-51 using invar pendulums. A national gravity base station was established at Melbourne. Subsequent comparisons with gravimeter ties suggest that the pendulum value is about 2 mgal low. The mean standard error of gravity differences from Melbourne to the other stations is about 0.6 mgal. Free air, Bouguer, and isostatic anomalies have been calculated for all stations; the latter two are predominantly negative. The isostatic anomalies are for both Airy-Heiskanen and Pratt-Hayford hypotheses, and for four different assumed crustal thicknesses in each case. A degree of isostatic compensation is present, but some large anomalous areas are uncompensated. — V. S. N.

- 187-318. Mann, Virgil I., and Zablocki, Frank S. Gravity features of the Deep River-Wadesboro Triassic basin of North Carolina: Southeastern Geology, v. 2, no. 4, p. 191-215, 1961.

Gravity studies made over the Deep River-Wadesboro Triassic basin, North Carolina, suggest that this basin is not a significant gravitational feature. The basin is best outlined by gravity profile maps aligned normal to the axis of structure. A study of the profiles suggests that the basin locally reaches a depth of at least 8,000 feet and in places has graben-like features. It may be traced under the Atlantic Coastal Plain overlap by locating the easily recognized discontinuity in the profile that represents the Jonesboro fault. It is hoped that in the future specific rock types in the Piedmont may be outlined by this gravity profile technique. — V. S. N.

- 187-319. Lum, Daniel. Gravity measurements east of the Black Hills and along a line from Rapid City to Sioux Falls, South Dakota: South Dakota State Geol. Survey Rept. Inv., no. 88, 26 p., 1961.

A simple Bouguer gravity anomaly map compiled from data of more than 500 stations in an area of 2,500 sq mi east of Rapid City, S. Dak., is presented. Results of a gravity traverse from the Black Hills eastward onto the Sioux uplift are shown in profiles that give the regional and residual Bouguer anomalies and outline the relief of the Precambrian basement. The principal facts for each gravity station are tabulated in the appendix. — V. S. N.

- 187-320. Cook, Kenneth L., and Berg, Joseph W., Jr. Regional gravity survey along the central and southern Wasatch Front, Utah: U. S. Geol. Survey Prof. Paper 316-E, p. 75-89, 1961.

The results of a regional gravity survey, made in 1954 in Salt Lake and Utah Counties, Utah, are reported. Gravity measurements were made at 1,100 stations in an area of about 5,000 sq mi, and results are compiled as a Bouguer gravity anomaly map on a regional geologic map. The regional gravity patterns reflect the present contrasts in the crust that are the product of several orogenies. Interpretations of the gravity data characterizing the Laramide and older structures (northern Utah highlands and the Uinta arch) and the Basin and Range structures are discussed. Gravity data indicate that in the valley areas lying between the great fault block comprising the Oquirrh Mountains, Boulder Ridge, and the northern East Tintic Mountains on the one side and the Wasatch fault block on the other, there is an intermontane trough more than 100 miles in length. It consists of a great belt of grabens and smaller fault blocks whose dislocations are varied and more complex than previously realized. From north to south the major grabens are the Farmington, Jordan Valley, Utah Valley, and Juab Valley; the major fault-block spurs are the eastern part of the Traverse Mountains and the spur in the Santaquin area. — V. S. N.

- 187-321. Worzel, J. Lamar, and Talwani, Manik. Latest results of gravity observations at sea from surface ships, in *Geodesy in the space age* (symposium): Ohio State Univ. Inst. Geodesy, Photogrammetry and Cartography Pub., no. 15, p. 116-126, 1961.

The development of the Graf and LaCoste-Romberg sea gravimeters is reviewed. Measurements over some interesting bottom features made with the Graf instrument from the U. S. S. *Compass Island* in the Atlantic and Mediterranean (see *Geophys. Abs.* 178-227) are discussed briefly. The results of about 5,000 miles of continuous observations in the Gulf of California with the LaCoste-Romberg instrument are reported. — D. B. V.

- 187-322. Ingall, L. N., and Copeland, R. J. Operational report on a gravity meter survey conducted on the Arctic Coastal Plain, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 1149-1152, 1961.

The personnel, logistics, equipment, mode of operation, and operational statistics are described for a gravimeter survey conducted in 1959 on the Arctic Coastal Plain. For mobility and speed of operation a helicopter and a Beaver aircraft were used. — V. S. N.

- 187-323. Weber, J. R. Comparison of gravitational and seismic depth determinations on the Gilman Glacier and adjoining ice-cap in northern Ellesmere Island, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic Geology, 1st, Calgary, Alberta, 1960, Proc., p. 781-790, 1961.

During 1957 and 1958, 12 bedrock profiles were constructed from results of seismic reflection surveys on the Gilman Glacier and on the icecap between the glacier and Mount Oxford; 200 gravity stations were established over the same area. The regional Bouguer anomaly calculated from ice thicknesses at selected stations along the seismic profile was extrapolated for the whole area, and with assumed specific gravities of ice and bedrock the ice thickness was calculated from the gravity measurements. Agreement between bedrock profiles as determined by the two methods was very close. It is concluded that a gravity survey, when supplemented by a few seismic soundings, can give a good indication of the shape of the bedrock and the ice thickness. — V. S. N.

- 187-324. Becker, Alex. Gravity measurements, in Jacobsen-McGill Arctic research expedition to Axel Heiberg Island, Preliminary Report 1959-1960: Montreal, McGill Univ., p. 109-114, 1961.

Measurements of the variation in the vertical component of gravity were made in the glacierized and coastal regions of Axel Heiberg Island, Canada, to investigate the thickness of ice in the White and Thompson Glaciers and in the McGill Icecap. Coastal measurements were taken to detect any spurious gravity gradients which would influence interpretation of measurements on the ice, as well as to check the isostatic equilibrium of the island. Results will be correlated with the seismic reflection observations (see Geophys. Abs. 187-580). Regional coastal gravity values are given in a table. — V. S. N.

- 187-325. Bullerwell, W. Geophysical investigations, in Geology of the country around Dungannon: Northern Ireland Geol. Survey Mem., no. 35, app. 7, p. 237-245, 1961.

The results are reported of gravity and magnetic surveys aimed at investigating broad rather than precise local geological structures in the area of the Dungannon (35) sheet. A Bouguer anomaly map and a vertical force magnetic anomaly map are included. Interpretation of results is handicapped by lack of continuity in the geophysical data across the area of the Lough Neagh and by the absence of reasonably precise knowledge about variation in thickness of the Antrim basalts. Additional geophysical work or drilling is needed. — V. S. N.

- 187-326. Poldini, E., and Inagaki, Morido. Les anomalies gravifiques de Genève et de ses environs [The gravity anomalies of Geneva and its environs]: Archives Sci. (Genève), v. 13, no. 3, p. 311-325, 1960.

The results of a gravity survey in the vicinity of Geneva, Switzerland, are presented in the form of six maps showing Bouguer anomalies, regional gradient, and residual anomalies, calculated on the basis of two different density values (2.4 and 2.6). Buried valleys in the Molasse bedrock can be traced and some idea of the thickness of their Quaternary fill can be deduced from the gravity data. — D. B. V.

- 187-327. Zaccara, Gaetano. Carta gravimetrica-rilievo della Calabria [Gravity-relief map of Calabria (with English abstract)]: [Italy] Servizio Geol. Boll., v. 80, no. 2-3, p. 209-213, 1959.

The first broad gravity survey of Calabria has revealed several significant structural features, some of which are similar to those of adjacent regions.

The area as a whole is characterized by a rise of the deep substratum corresponding to a general rise of the continental shelf; the north end of the Sicilian trough is represented by the south slope of the Aspromonte Range; and the most marked fractures have a northwest trend. — J. W. C.

- 187-328. Kántás, Karl. Geophysikalische Interpretationsfragen im Wiener Becken [Geophysical interpretation problems in the Vienna basin]: *Erdöl u. Kohle*, v. 14, no. 8, p. 600-606, 1961.

After an outline of the geology of the Vienna basin, the geophysical results obtained by telluric measurements and gravity surveys (vertical gradient) in the area, particularly with respect to the relief of the Flysch, the limestone, and the fault zone, are discussed. Where other methods fail to yield positive results or do so only indirectly, the telluric and vertical gradient methods can be used satisfactorily in this area. The Δg anomalies appear to characterize the structure as a whole, whereas the vertical gradient anomalies and the telluric anomalies reflect changes that occurred during or after sedimentation.

Two appendices are given. The first reviews torsion balance measurements made by Eötvös in 1915-16 in the Slovakian extension of the Vienna basin and measurements made by Schumann in Oberlaa, near Vienna, in 1919-21. The second suggests the possibility of direct measurement of gravity derivatives. — D. B. V.

- 187-329. Stoenescu, Scarlat. Asupra semnificației unor raporturi gravimetrice majore în sudul bazinului Transilvaniei [On the significance of some relationships of gravity maximums in the south of the Transylvanian basin (with Russian and French summaries)]: *Acad. Române Studii și Cercetări de Geologie-Geografie*, v. 5, no. 3, p. 539-546, 1960.

A gravity maximum occurs in the south of the Transylvanian basin between the Tîrnava-Mare and Olt Rivers. This feature appears on the Bouguer map as a 15 mgal high with a gradient of 1.5 mgal per km. The anomaly is due to the juxtaposition of a block of high density on the south and a block of low density on the north. Deep drilling confirms the gravity interpretation. — J. W. C.

- 187-330. Airinei, Ștefan. Studii asupra efectului gravimetric de la limita externă a flîșului cretacic din Muntenia orientală (dintre văile Prahova și Teleajen-Drajna) [Study of the gravity effect of the outer limit of the Cretaceous flysch of eastern Muntenia (between the valleys of the Prahova and Teleajen-Drajna) (with Russian and French summaries)]: *Acad. Române Studii și Cercetări de Geologie-Geografie*, v. 5, no. 3, p. 547-571, 1960.

A general description is given of the gravity effects in the zone of the outer margin of the Cretaceous flysch of eastern Muntenia as determined from oil exploration in 1953-56. A gravity minimum occurs along this margin, and it in turn is marked by several negative peaks. The minimum value of gravity in some areas is due apparently to the cumulative effect of flexures in the Cretaceous rocks, which are more dense than the overlying Cenozoic deposits. The local minimum gravity anomalies are probably caused by salt masses and oil-gas deposits. — J. W. C.

Ștefănescu, Sabba [S.]; Stoenescu, Scarlat; Airinei, Ștefan; Botezatu, Radu; Popovici, Dorin; and Ionescu, Florian. Geophysical surveying for iron near Constanța (Rumanian People's Republic). See *Geophys. Abs.* 187-521.

- 187-331. Shengelaya, G. Sh. K voprosu kolichestvennoy interpretatsii tbilisskoy gravitatsionnoy anomalii [On the problem of quantitative interpretation of the Tbilisi gravity anomaly]: Akad. Nauk Gruzin. SSR Soobshch., v. 19, no. 6, p. 668-776, 1957.

Gravity measurements were made along two profiles of the Tbilisi gravity anomaly in the Georgian S. S. R. for determination of the depth to basement. In the Dzhavakhet zone of the Artvini-Somkhit block this depth is 8 km, and it varies from 2 to 0 km in the Bolnisi, Borchali, and Asureti zones. — A. J. S.

Balavadze, B. K., and Shengelaya, G. Sh. Main features of the crustal structure of the Greater Caucasus according to gravimetric data. See Geophys. Abs. 187-361.

- 187-332. Mufti, Irshad. A gravity survey of Quetta and Mastung valleys: Pakistan Jour. Sci. and Indus. Research, v. 4, no. 1, p. 15-20, 1961.

Data from a gravity survey of the Quetta and Mastung valleys support geological evidence that large scale faulting was a primary factor in the origin of the valleys. Of particular interest are cross faults which must have modified the early drainage and have been a major factor in controlling groundwater aquifers. — V. S. N.

- 187-333. Yokoyama, Izumi. Gravity survey on the Aira caldera, Kyushu, Japan: Nature, v. 191, no. 4792, p. 966-967, 1961.

A gravity survey was made in 1960 of the Aira caldera in Kyushu, Japan, using a North American gravimeter. This caldera is one of the largest in the world; the diameter is about 20 km. It occupies the innermost part of Kagoshima Bay and is bounded on the south by the peninsula of Sakurajima, an active volcano. A relatively low Bouguer anomaly coincides with the caldera depression. The active volcano has hardly any effect on the shape of the anomaly.

The anomaly is of the same type and magnitude as that at Kuttayaro caldera (see Geophys. Abs. 179-232). It is concluded that coarse material with a density 0.3-0.5 g per cm³ less than that of the surrounding rock underlies the caldera to a depth of 3-4 km. The total mass deficit responsible for the anomaly is calculated as 1.6×10^{11} metric tons; the amount of material ejected during formation of the caldera was estimated by Koto (1916) as 1.6×10^{11} m³. — D. B. V.

- 187-334. McMurtrie, I. H. Supplementary gravity traverses over Bungalow aeromagnetic anomaly near Cowell: South Australia Dept. Mines Mining Rev., no. 111, p. 89-93, 1961.

Supplementary gravimeter traverses were run over the Bungalow aeromagnetic anomaly near Cowell, South Australia, to delineate further the anomaly for a planned drilling program. The drilling results suggest that the magnetic anomaly is caused by magnetite and the gravity anomaly by the occurrence of bands of more dense rock (with which the magnetite is associated) within the country-rock. Profiles of gravity values are given, but no further work is recommended. — V. S. N.

- 187-335. Moorcroft, E., and Dowling, D. R. Gravity and magnetic surveys over aeromagnetic anomaly—Hundred of Chandada: South Australia Dept. Mines Mining Rev., no. 111, p. 94-100, 1961.

Vertical magnetometer and gravimeter traverses have been carried out over an anomaly disclosed by aeromagnetic survey near Cungena, Eyre Peninsula. From a study of the results the presence of a large body of rock slightly denser and more magnetic than the surrounding rock has been inferred. The depth below surface is uncertain and a drilling program to test the depth of the cover is recommended. — Authors' abstract

- 187-336. Bilotserkovets', Yu. I. Pro shchil'nost' vugillya i vmishchaynchikh porid Donbasu [On the density of the coal and country rock of the Donets Basin]: Akad. Nauk Ukrayin. RSR Dopovidī, no. 7, p. 900-903, 1961.

Throughout the Donets Basin, the density of the coal differs from that of the enclosing rock by 0.5-1.7 g per cm³. Changes in the density of the coal itself are confined to the range of 0.0-0.7 g per cm³ and are due chiefly to difference in ash content and porosity. — A. J. S.

- 187-337. Prozorovich, E. A. K voprosu o faktorakh uplotneniya osadochnykh gornykh porod [On the problem of factors of consolidation of sedimentary rocks]: Azerbaydzhan. Nauchno-Issled. Inst. po Dobyche Nefti Trudy, v. 4, p. 244-270, 1956.

One of the essential factors that determine the validity of interpretation of gravity anomalies is the reliability of data on the density of the rocks in the area investigated. Specific gravity and total porosity of sedimentary rocks in general and of the Tertiary sedimentary rocks of Azerbaijan in particular are discussed. — A. J. S.

HEAT AND HEAT FLOW

- 187-338. Lubimova, H. A. [Lyubimova, Ye. A.]. On processes of heat transfer in the earth's mantle: Jour. Physics of Earth [Tokyo], v. 8, no. 2, p. 11-16, 1960.

Three components of thermal conductivity—radiative, lattice, and exciton—that lead to heat transfer in the earth are analyzed. The patterns of radiative and lattice thermal conductivity that have been discussed previously by Lyubimova and others (see Geophys. Abs. 174-214, 178-249, 181-318) are reviewed, and the process of energy transfer by the excited states of atoms or excitons is discussed. The comparative distribution of the three components in the earth's mantle is given in a graph, and it is shown that at high temperatures exciton thermal conductivity increases, whereas radiative thermal conductivity dies away. When allowance is made for the exciton component, it is seen that the minimum of thermal conductivity in the upper layers of the mantle becomes sharper than previously supposed; thermal conductivity at the base of the mantle exceeds its value at the surface by almost two orders of magnitude. The exciton component, however, does not change the process of thermal history outlined earlier (see Geophys. Abs. 174-214). Calculations of heat flow and temperature distribution for different moments of time are given for the case of infinitely great thermal conductivity in the layer of the mantle lying below the level of the minimum thermal conductivity. The earth began to cool 1.5×10^9 yr ago with a heat flow exceeding by 5 to 8 times that currently observed. This indicates that heat convection on a global scale has stopped and that the earth's interior is heating anew. Convective transfer of heat in the earth's mantle is not denied but is believed to have been local in

character in the form of convection of heat when sialic material was transferred from mantle to surface in the process of crust formation. — V. S. N.

- 187-339. Lubimova, H. A. [Lyubimova, Ye. A.]. On conditions of magmatism origin and role of volcanic activity in the thermal regime of earth's crust: *Jour. Physics of Earth* [Tokyo], v. 8, no. 2, p. 17-21, 1960.

It has been established that thermal conductivity in the upper mantle decreases to a minimum at about 50-100 km and that this minimum hinders the intensive loss of heat through the surface and leads to a rapid increase of temperature at great depths; conditions for cooling and contraction of the earth as a whole never existed. The temperature at depths from 50-200 to 500-700 km reached the melting point at 2 to 3 billion years after the formation of the earth. A belt was thus formed in the upper mantle in which conditions were favorable for the origin of magma and the differentiation of matter; magmatism did not exist before 3×10^9 yr ago. The melting belt was not continuous but consisted of local melting pockets at points of weakened pressure. The lower boundary of the "differentiation belt" is just at the depth of deep earthquakes—600 to 700 km. The C-layer at 600 to 900 km and the low velocity layer at 150 km may be traces of former molten layers that underwent differentiation resulting in rise of silicic phases and sinking of those richer in iron. Volcanic and intrusive activity were the main processes by which easily fused and volatile fractions were brought to the earth's surface. The geological periods associated with rise of material from the mantle alternate with periods of relative rest. — V. S. N.

- 187-340. Levin, B. J. [B. Yu.], and Majeveva [Mayeva], S. V. On the thermal history of the earth: *Annali Geofisica*, v. 14, no. 2, p. 145-155, 1961.

The thermal history of an initially cold earth is calculated for several models. The formation of the crust is considered to be a continuous process that started 3×10^9 yr ago. If radiative conductivity is high, the radioactive element content of the earth need not be as large as formerly believed in order to account for observed heat flow. The calculated difference between heat flow for oceanic and continental regions is only 30-40 percent; this can explain why systematic differences between continental and oceanic heat flow are not observed. — D. B. V.

- 187-341. Sherratt, A. F. C., and Hinsley, F. B. A heating experiment to determine the thermal constants of rocks in situ [with discussion]: *Mining Engineer*, no. 9, p. 700-711, 1961.

An experiment is described in which a length of roadway within a mine was heated by electric tubular heaters with the object of producing data from which the thermal constants of the rocks surrounding the roadway could be determined. The effect of the heating on the temperature of the strata was measured by thermocouples in boreholes, and the thermal constants of the strata in their natural state were determined by comparing the experimental temperatures with theoretical relationships. The results show surprising variations for different directions with respect to the bedding planes and are low in comparison with previously published values; they are illustrated both graphically and in tables. — V. S. N.

- 187-342. Horai, Ki-iti, and Uyeda, Seiya. Studies of the thermal state of the earth. The fifth paper: Relation between thermal conductivity

of sedimentary rocks and water content: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 199-206, 1960.

The relation between thermal conductivity of a soft porous shale and water content was studied experimentally. It was found that thermal conductivity increases as water content increases from zero to about 14-16 percent by weight (saturation of pores), then decreases. This is interpreted as follows: Until the pores are saturated the water replaces air, a poor heat conductor; but as the rock becomes oversaturated the percentage of water increases at the expense of solid particles, which have greater thermal conductivity. The variation of thermal conductivity in the oversaturated region agrees with Bullard's model (see Geophys. Abs. 176-207). That model is extended here to account for the features in the undersaturated region as well. (See also Geophys. Abs. 176-210, 179-239, 186-415, -427, -428.)—D. B. V.

- 187-343. Lubimova, H. A. [Lyubimova, Ye. A.], Lusova, L. M., Firsov, F. V., Starikova, G. N., and Shushpanov, A. P. Determination of surface heat flow in Mazesta (USSR): *Annali Geofisica*, v. 14, no. 2, p. 157-167, 1961.

Results of temperature and thermal conductivity measurements made in three boreholes in the Matsista region of the U. S. S. R. are presented. Heat flow calculated from these measurements is 0.88×10^{-6} cal per cm^2 per sec. (See also Geophys. Abs. 186-423.)—D. B. V.

- 187-344. Khrebtov, A. I. Vnutrenneye teplo neftegazonosnykh ploshchadey [Internal heat of oil and gas areas]: *Akad. Nauk SSSR Doklady*, v. 136, no. 5, p. 1069-1072, 1961.

The results of temperature logging in the lower 200-300 m of the Maykop shales in various oilfields of the Central Caspian since 1948 show positive anomalies ranging from 1.9°C in the Ipatov research borehole to 4.5°C in the Aleksandrov oilfield, with an average of 3.1°C . These anomalies are due to the generation of gas-forming hydrocarbons in the shales (which contain about 1 percent bitumens). There is no evidence that the anomalies are related to the radioactivity of the Maykop rocks. —D. B. V.

- 187-345. Dzhibuti, S. S. Geotermicheskiye usloviya Zapadno-Turkmen'skogo artesianskogo basseyna (primenitel'no k resheniyu nekotorykh voprosov gidrogeologii i neftegazonosnosti [Geothermal conditions of the west Turkmen artesian basin (applicable to the solution of some problems of hydrogeology and oil and gas possibilities)]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 5, p. 95-100, 1961.

Temperature data measured in springs and boreholes in different oil- and gas-bearing structures in the west Turkmen basin are summarized in a map of geoisotherms at 2,000 m below sea level. This map reflects the geologic structure. The results suggest that the geothermal method can serve as one of the criteria in the prospecting of oil and gas deposits. (See also Geophys. Abs. 186-424.)—D. B. V.

- 187-346. Elizondo, Jesús Ruiz. Prospection of geothermal fields and investigations necessary to evaluate their capacity: United Nations Conf. on new sources of energy, Rome, Italy, 1961, Gen. Rept., 79 p., 1961.

Following an introductory statement on geothermal energy, a generalized description and tabulation of known geothermal fields in Italy, New Zealand, Iceland, United States, Mexico, Japan, U.S.S.R., and El Salvador are given. Methods and techniques used in geothermal prospecting, some views on the origin of the heat and steam in geothermal zones, elements in evaluation of the capacity of geothermal zones, the problem of silica and calcite deposition, and costs and other economic aspects are discussed also. A list of topics proposed for discussion and a list of papers by title and author presented at the conference are included. — V. S. N.

- 187-347. Ovchinnikov, A. M. Termy Bolgarii [The hot springs of Bulgaria]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 18, p. 133-138, 1960.

There are several hundred hot springs in Bulgaria. The three main types—nitrogenous, carbonic, and methane-bearing—are discussed briefly. Areas worth investigating for possible geothermal energy sources are mentioned. — D. B. V.

- 187-348. Hu, Ch'ang-lin. Mineral water of the upper reaches of the Sha River in Lu-Shan Hsien, Honan Province [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 12, p. 16-18, 1959; translated by U. S. Joint Publications Research Service, JPRS no. 7853, p. 32-46. 1961.

Hot mineral springs are found in four areas—Han-ch'ang, Hsia-t'ang, Chung-t'ang, and Shang-t'ang—along the upper reaches of the Sha River, Honan Province, China. The area is characterized by pre-Sinian metamorphic and Sinian igneous rocks cut by a major east-west fault zone that is paralleled by the river. The temperature range is from 43°C to 60°C. It is concluded that these thermal waters rise along the fault plane from a depth calculated to be at least 1,500 m on the assumption that the geothermal gradient is 1° per 33 m. Variation in temperatures of individual springs is a result of the admixture with cold surface ground water. — V. S. N.

- 187-349. Mou, Hung-wei. Hot springs of the fold area of southeast Szechuan Province [translation from Chinese]: Shui-wen Ti-chih Kung-ch'eng Ti-chih [Hydrogeology and Engineering Geology], no. 12, p. 19-21, 1959; translated by U. S. Joint Publications Research Service, JPRS no. 7853, p. 47-64, 1961.

Numerous warm springs flow from the karst area of the Chia-ling-chiang limestone in the anticlines of southeastern Szechuan Province, China. The water is stored in both solution channels and tectonic fractures in the limestone and is held by impervious layers both above and below the formation. The springs appear where the folds have been cut transversely by rivers. The waters are heated as a result of the depth from which they come and not by association with volcanic activity. The geothermal gradient in the Szechuan area is about 1°C per 41.5 m; thus, the water must come from a depth greater than 1,500 m. — V. S. N.

- 187-350. Hughes, T. D. Thermal Springs, Hastings: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 44-46, 1961.

The thermal springs at Hastings in southern Tasmania are believed to be due to the effect of temperature gradient on water coming from a great depth;

in this area it is estimated that the temperature rises 1°F for each 66 feet of depth. The waters, originally surface waters descending along synclinal dolomite beds, rise under hydrostatic pressure from a depth of 2,000 feet along a major fault plane to reach the surface. — V. S. N.

- 187-351. Swartz, J[oe]l H., and Raspet, R[udolph]. Thermal shock and its effect on thermistor drift: *Nature*, v. 190, no. 4779, p. 875-878, 1961.

It was found in studies of permafrost problems in Alaska that thermistor calibrations were disturbed by the vulcanization process used to seal the cable slits made for insertion of the thermistors. In order to test the hypothesis that the effect was due to thermal shock rather than to chemical effects, 12 thermistors were placed in a clear mold and raised to vulcanizing temperatures for one hour. All showed the same disturbance as those vulcanized in a cable. Subsequently some 80 thermistors were investigated for the effects of thermal shock, and their subsequent calibration was studied by recalibrations at approximately regular intervals. Results are presented here.

It is concluded that thermistors that have been subjected to thermal shock should be allowed a sufficient rest period to return to a normal drift rate. They should be recalibrated just prior to or just after subsequent measurements, or both if highest accuracy is necessary; if possible they should be kept continuously at the temperature being measured for the entire measurement period. With these precautions drift can be reduced to very small values, which may often be further reduced by properly applied corrections. — D. B. V.

- 187-352. Uyeda, Seiya; Tomoda, Yoshibumi; Horai, Ki-iti; Kanamori, Hiroo; and Futi, Hidetaka. Studies of the thermal state of the earth. The seventh paper: A sea bottom thermogradimeter: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 2, p. 115-131, 1961.

An apparatus for measuring the geothermal gradient in the sea bottom is described, with photographs and schematic diagrams. It consists of a probe containing two pairs of thermistors and a recorder housed in a pressure-resistant waterproof steel container. It can be attached to a core sampler. The two pairs of thermistors give the temperature differences between the bottom and the top and between the bottom and the middle point of the probe. Probes of different lengths are used for different conditions of sea bottom, the longest being 4.5 m. Temperature differences in the interval 0°C - 2°C can be recorded with an accuracy of 0.001°C in about 2.5 hours. Preliminary tests indicate that the apparatus will serve to determine terrestrial heat flow through the ocean bottom. — D. B. V.

- 187-353. Holz, Hans-Werner. Aragonit-Sinter als geologisches Thermometer [Aragonite sinter as a geologic thermometer]: *Deutsch. Geol. Gesell. Zeitschr.*, v. 112, pt. 3, p. 513-514, 1960 (1961).

Different sinters have been deposited in two caves 9 km apart in Middle Devonian coral limestones in the Rhenish Schiefergebirge about 50 km east of Cologne, Germany; in the Wiehl cave the sinter consists only of calcite, whereas in the Ründeroth cave it consists only of aragonite. Moore (1956) suggested that aragonite sinter is a paleotemperature indicator, developing instead of calcite when mean annual temperature exceeds 60°F (15.6°C). Such temperatures are unknown in central Europe in postglacial time, and it cannot be determined whether the sinter was deposited during or before the Pleis-

tocene. It is suggested that the deposition of aragonite instead of calcite was governed by the presence of magnesium ions—there are patches of dolomitic limestone at the Runderoth cave—rather than by temperature control. — D. B. V.

- 187-354. Legget, R. F., Dickens, H. B., and Brown, R. J. E. Permafrost investigations in Canada, in *Geology of the Arctic*, v. 2: *Internat. Symposium on Arctic Geology*, 1st, Calgary, Alberta, 1960, Proc., p. 956-969, 1961.

A review is given of a program initiated in Canada to study climatic and terrain factors affecting the existence of permafrost at specific locations as a means of improving prediction of permafrost conditions for engineering and geologic purposes. The object is to investigate the thermal characteristics of the terrain components and to seek correlations between these, the climatic factors, and the distribution of perennially frozen ground. — V. S. N.

- 187-355. Scott, Ronald F. Heat transfer in soil involving change of state: *Géotechnique*, v. 11, no. 2, p. 144-153, 1961.

Heat-flow processes in the ground which involve soil-moisture freezing and thawing are discussed with emphasis on methods for estimating or predicting the depths of freeze or thaw in moist soil; data from Alaska and Greenland are used. Previous work on evaluation of soil thermal properties and measurement techniques is reviewed; the effect of soil heat property variation, current methods of computing the depth of thaw in permafrost using air temperature and correction coefficients, and a new method based on heat flow into the ground are considered; and, finally, methods of measurement of heat flow into the soil are discussed. — V. S. N.

INTERNAL CONSTITUTION OF THE EARTH

- 187-356. Bott, M[artin H[arold] P[hillips]. The granitic layer: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 207-216, 1961.

The negative gravity anomalies observed over granite masses show that the upper part of the "granitic layer" is denser than granite. It is suggested that the denser and more mafic (metasedimentary or dioritic) upper layer is underlain by a truly granitic zone. This hypothesis can be tested seismologically. As it implies that the low-velocity channel is directly connected to the surface by batholiths, a study of the amplitude variation of L_g (particularly L_{g2}) on and around a large batholith should be of considerable interest. A seismic refraction study of a large granite mass should determine the depth of the underlying high-velocity rocks. The proposed model of the continental crust is stated in tabular form and illustrated diagrammatically. — D. B. V.

- 187-357. Lyustikh, Ye. N., and Saltykovskiy, A. Ya. O nekotorykh gipotezakh proiskhozhdeniya granitnogo sloya Zemli [On some hypotheses of the origin of the granitic layer of the earth (with English abstract)]: *Geokhimiya*, no. 4, p. 371-373, 1960.

It is calculated that all the silicic and sedimentary rocks of the earth's crust cannot have been formed from basic rocks, because the excess of iron and magnesium that should result (as iron ores and dolomites) would be twice as great as the total mass of the sedimentary rocks. — D. B. V.

- 187-358. Shimazu, Yasuo. Regional metamorphism and physical state of the crust [in Japanese with English abstract]: *Zisin*, ser. 2, v. 14, no. 1, p. 1-17, 1961.

The physical state of the crust and upper mantle are inferred from the results calculated from models of three types of metamorphic reactions and associated variations of temperature and water pressure during regional metamorphism. The flow diffusivity of water within the crust is estimated to be on the order of 10^{-2} cm^2 per sec. It is shown that normal temperature gradient has no significance during metamorphism and that the heat flow from the mantle toward the crust is an essential factor in determining the types of regional metamorphism. An unusual feature of the Sambagawa metamorphic belt in southwestern Japan is discussed briefly in relation to the physical structure of the earth's interior. — V. S. N.

- 187-359. Glangeaud, Louis. Origine profonde des volcans et structure de la croûte terrestre [Deep origin of volcanoes and structure of the crust]: *Géodésie et Géophysique Comptes Rendus*, p. 43-49, 1959 [1960].

According to recent theories the eruptive rocks and volcanoes are supplied by two categories of magmas of different origin: (1) The peridotite and basaltic magmas which are the primary magmas mobilized in the upper mantle and lower crust, and (2) the granitic (sialic) magma which appears under different conditions and indirectly provides the sedimentary rocks transformed by metamorphism and granitization. The emphasis in this paper is on the formation of the granites and of the sialic magmas. Experimental work on temperatures and pressures necessary to produce granite in the laboratory is reviewed briefly, and the theory that heterogeneous sediments may sink to a zone where temperatures and pressures would cause certain elements to fuse to granite is discussed. These liquid phases would gradually separate from the solid phases, crystallize, and reassemble to form a rhyolitic magma. A highly metamorphosed series would be formed eventually at a zone between 10 and 22 km in depth (based on geologic evidence) that is called the mesozone or middle crust. Seismological evidence indicates that the granitic crust extends nearly 20 km in depth. It is suggested that variations in seismic velocities in the crust may be explained by the presence of liquid pockets where new granites are forming. Some volcanoes are shown to be supplied by both basaltic and granitic magmas; Mont-Dore is cited as an example. — V. S. N.

- 187-360. Cisternas, Armando. Crustal structure of the Andes from Rayleigh wave dispersion: *Seismol. Soc. America Bull.*, v. 51, no. 3, p. 381-388, 1961.

When records from a Benioff shortperiod seismograph at Huancayo, Peru, are digitalized and then passed through a low-pass filter to get the long-period waves, the dispersion curves of Rayleigh waves for Andean paths can be computed from seismograms that otherwise would be unusable. Comparison with the empirical curve for a "normal" continental crust and with specially computed theoretical models indicates a crustal thickness of the order of 50 km. For periods between 20 and 25 sec the observed group velocity shows abnormally low values. — D. B. V.

- Porkka, M. T. Surface wave dispersion for some Eurasian paths, II. Love waves. See *Geophys. Abs.* 187-131.

- 187-361. Balavadze, B. K., and Shengelaya, G. Sh. Osnovnyye cherty struktury zemnoy kory Bol'shogo Kavkaza po gravimetricheskim dannym [Main features of the crustal structure of the Greater Caucasus according to gravimetric data]: Akad. Nauk SSSR Doklady, v. 136, no. 6, p. 1328-1334, 1961.

The results of gravity surveys in the Greater Caucasus are interpreted in terms of crustal structure. Maps show contours on the Paleozoic crystalline basement and on the M-discontinuity, together with data from other sources including deep drilling, seismic depth sounding, and earthquakes. From an area of outcrop in the central part of the mountains, the basement descends to depths of 1-8 km in the Peri-Caucasus, 6-8 km and 14-16 km in the Taman and Apsheron Peninsulas, respectively, and 0-14 km in the Rion-Kura depression. The basalt layer, in contrast, is deepest in the central and eastern parts (about 32 km) and rises to 20 km toward the periphery. The M-discontinuity in general follows the basalt layer but is deeper under the central part (64 km) than under the eastern (56 km).

The root under the Greater Caucasus, therefore, is due mainly to thickening of the granitic layer, but the basaltic layer, depressed beneath it, is also somewhat thickened; a root is lacking, however, in the high mountainous Kazbek area between the central and eastern parts. These results agree fully with those of other geophysical investigations. — D. B. V.

- 187-362. Savarenskiy, Ye. F., and Shechkov, B. N. Stroyeniye zemnoy kory Sibiri i Dal'nego Vostoka po dispersii voln Lyava i Releya [Structure of the crust of Siberia and the Far Eastern Region according to the dispersion of Love and Rayleigh waves]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 5, p. 700-704, 1961.

The thickness of the earth's crust determined for Siberia and the Far Eastern Region was found to be 25-35 km from the dispersion of Love waves, and 35 km from the dispersion of Rayleigh waves. By comparing the observed dispersion of the group velocities of both types of surface waves, it was found that the granite layer in Siberia and the Far Eastern Region is 1.5-2.00 times thicker than the basaltic layer. — A. J. S.

Fedotov, S. A., Averjanova [Aver'yanova], V. N., Bagdasarova, A. M., Kuzin, A. P. [Kuzin, I. P.], and Tarkanov [Tarakanov], R. Z. Some results of the detailed study of the south Kurile Islands seismicity. See Geophys. Abs. 187-110.

- 187-363. Aki, Keiiti. Crustal structure in Japan from the phase velocity of Rayleigh waves. Part 1. Use of the network of seismological stations operated by the Japan Meteorological Agency: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 2, p. 255-283, 1961.

The phase velocities of Rayleigh waves with 20-30 sec periods were determined for different parts of Japan using the records of the Samoan earthquake of April 14, 1957, obtained at the network of seismological stations operated by the Japan Meteorological Agency. An accuracy of 1-1.5 percent was attained by means of the least squares method.

The results, together with those of refraction studies in Japan, suggest that Press' standard phase velocity curves (see Geophys. Abs. 168-192) do not apply to Japan. A 5.5 percent reduction from the standard velocities in the crust and upper mantle gives better agreement with values obtained from the refraction studies, and yields crustal thicknesses that agree very well with those

determined in these and other studies. Crustal thicknesses determined for seven regions in Japan are tabulated.

The positive correlation between Rayleigh wave phase velocities and positive Bouguer gravity anomalies found by Ewing and Press in the United States (see *Geophys. Abs.* 176-230) was also noted here; however, the relationship is slightly different in southwestern Japan from that for central and northeastern Japan, suggesting a relationship to local geologic and geotectonic conditions.

The wave front chart suggests that Rayleigh waves are refracted laterally at the andesite line in Japan. — D. B. V.

- 187-364. Research Group for Explosion Seismology. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 1. Explosions and seismic observations: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 2, p. 285-326, 1961; also in Zisin, ser. 2, v. 14, no. 3, p. 150-167, 1961. Mikumo, Takeshi; Otsuka, Michio; Utsu, Tokuji; Terashima, Tsutomu; and Okada, Atsui. Crustal structure in central Japan as derived from the Miboro explosion-seismic observations. Part 2. On the crustal structure: *ibid.*, v. 39, pt. 2, p. 327-349, 1961; also in Zisin, ser. 2, v. 14, no. 3, p. 168-188, 1961.

Six seismic projects were based on the large-scale quarry explosions at a damsite in the Miboro valley near Sirakawa, Gifu Prefecture, Japan. The first paper gives details of the explosions and tabulates the observations at 75 temporary stations. Many seismograms are reproduced.

The second part interprets these results in terms of crustal structure in the Kwanto, Tyubu, Kinki, and Tyugoku districts in central Japan. Two probable models are shown for eastern and western profiles. In the eastern profile the first model shows downwarping of the first and second layers to maximum depths of 9 km and 38 km, respectively; in the second model the mean depth of the second discontinuity (regarded as being the M-discontinuity) is about 36 km. In the two western profiles the maximum depth of the M-discontinuity is about 36 km in the first model, and its mean depth 27-29 km in the second model. This structure corresponds at least qualitatively to the Bouguer gravity anomaly and to the structure deduced from its spectrum. — D. B. V.

- 187-365. Matuzawa, Takeo, Matumoto, Tosimatsu, and Asano, Shuzo. On the crustal structure derived from observations of the second Hokoda explosion: Tokyo Univ. Earthquake Research Inst. Bull., v. 37, pt. 3, p. 509-524, 1959.

This is the same as the paper published in Zisin, ser. 2, v. 13, no. 2, p. 78-89, 1960 (see *Geophys. Abs.* 184-432). — D. B. V.

- 187-366. Santo, Tetsuo A[kima]. Rayleigh wave dispersions across the oceanic basin around Japan (Pt. 3)—On the crust of the south-western Pacific Ocean: Tokyo Univ. Earthquake Research Inst. Bull., v. 39, pt. 1, p. 1-22, 1961.

The physical conditions governing the deviation of Rayleigh wave dispersion from a purely oceanic character, due to the presence of islands or atolls and observed particularly in the western Pacific and around the "andesite line" in the southwestern part, have been investigated. Correlation between Rayleigh wave dispersion and average sea water depth is disturbed around the "ande-

site line"; this anomaly seems to be due to the presence of a volcanic rock layer of variable thickness overlying the basalt layer.

Data are as yet insufficient for complete estimation of local structures by the group velocity method, but there seem to be two small regions of oceanic crust on the continental side of the "andesite line," one in the Marianas Sea and the other in the region bounded by New Caledonia, the Fiji Islands, and New Zealand. — D. B. V.

- 187-367. Kovach, Robert L., and Press, Frank. Rayleigh wave dispersion and crustal structure in the eastern Pacific and Indian Oceans: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 202-216, 1961.

Rayleigh wave dispersion data, presented for a number of earthquakes having their epicenters in the Easter Island area and recorded at Pasadena, differ in a small but significant way from those obtained for Pacific Ocean basin paths. The discrepancies are resolved by addition to the theoretical model of a modified low velocity zone in the upper mantle; the modification consists of lowering the mean shear velocity in the upper mantle to 4.5 km/s. It is further demonstrated that it is possible to obtain a model compatible with observed compressional velocities and dispersion data which does not require changing Poisson's ratio and consequently reducing the shear velocities in the upper mantle; this is accomplished by reducing the thickness of the 8.2 km/s layer to the minimum required to give a refraction arrival. The mean shear velocity of 4.5 km/s implies a "soft" upper mantle layer along the Easter Island-Pasadena path. Dispersion data also show that the mean thickness of unconsolidated sediments between Easter Island and Peru is 0.57 km.

Rayleigh wave dispersion data for Indian Ocean shocks recorded at Wilkes Station in Antarctica are in agreement in the period range 25-37 sec with the model assumed for the Easter Island-Pasadena data. — D. B. V.

- 187-368. Kovach, Robert L., and Press, Frank. Surface wave dispersion and crustal structure in Antarctica and the surrounding oceans: *Annali Geofisica*, v. 14, no. 2, p. 211-224, 1961.

Love and Rayleigh wave data of Evison and others (see Geophys. Abs. 185-364) from five earthquakes recorded at Hallett Station, Scott Base, and Mirny in Antarctica have been reinterpreted in the light of more recent theoretical calculations on a digital computer. A mean crustal thickness of about 40 km is indicated for East Antarctica; an indication of 30 km for West Antarctica is less certain. Evison's determination of 10 km for crustal thickness in the south Indian Ocean is unproved because Love wave dispersion data for more than 22-sec period cannot distinguish between a 5-km and a 10-km oceanic crust. — D. B. V.

Dohr, G[erhard]. On the observations of deep reflections within the compass of routine seismic reflection surveys. See Geophys. Abs. 187-584.

- 187-369. Sheynmann, Yu. M. Poverkhnost' Mokhorovichicha, glubina zarochdeniya magm i razmeshcheniye ul'trabazitov [Mohorovičić surface, depth of origin of magmas, and distribution of ultrabasics (with English summary)]: *Sovetskaya Geologiya*, no. 8, p. 31-44, 1961.

The problem of the composition of the subcrust is considered, and preference is given the periodite hypothesis. Geophysical data show that basaltic

magmas form below the M-discontinuity by partial melting of ultramafic material. The rise of such melts into the upper parts of the crust results in a deficiency of the components of basalt in the peridotite immediately below the M-discontinuity. Peridotites that have not lost their light constituents must lie at greater depth. Such a distribution of rock types can account for the low velocity layer at the top of the mantle.

Basaltic magmas appear most frequently within oceans and platforms. If the temperature is raised locally, a complete melting of mantle material occurs; examples are the highly alkaline ultramafic magmas of the Pacific Ocean. Melting of upper mantle material devoid of the constituents of basalt takes place under the conditions of high temperature beneath geosynclines, and the low alkali peridotites of the folded belts are thereby produced. A later and more intensive heating of the deep zones under geosynclines results in melting of mountain roots and generation of granitic magma. — J. W. C.

Lubimova, H. A. [Lyubimova, Ye. A.]. On conditions of magmatism origin and role of volcanic activity in the thermal regime of earth's crust. See *Geophys. Abs.* 187-339.

187-370. Birch, Francis. Composition of the earth's mantle: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 295-311, 1961.

Measurements of the velocity of compressional waves in silicates and oxides having a range of density from 2.6 to 5 g per cm³ suggest a simple dependence of velocity upon density and mean atomic weight. Consequences of the assumption that this relation remains valid at high pressures are examined with reference to the composition of the mantle, especially of the transition layer. It appears probable that the abnormally high rate of increase of velocity with depth in the transition layer may be accounted for principally in terms of phase change, with little change of composition. Recent studies with strong shock waves are examined in connection with the composition of the core; the evidence is unfavorable to the hypothesis of a metallic core of light elements, but is consistent with a core of iron alloy. — Author's summary

187-371. Hales, A. L. A weak layer in the mantle? *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 312-319, 1961.

The paper discusses the effect of a weak layer in the upper mantle on the deformation of the crust arising from atmospheric loading, and on the isostatic compensation process. It also points out that S-phases with periods of 1 sec are much more strongly damped than S-phases with periods of 10 sec or more, and than P-phases with short periods. The damping arising from a liquid layer is proportional to the square root of the frequency and does not provide a satisfactory explanation. Scattering of the kind suggested by Jeffreys (see *Geophys. Abs.* 179-250) or any other mechanism leading to the firmoviscous law, gives rise to damping proportional to the square of the frequency and is sufficiently frequency sensitive to be consistent with the observations. The differences between P and S can only be accounted for in terms of different behaviour of the elastic constants for dilatational and distortional movements. — Author's summary

187-372. Vening Meinesz, F. A. Continental and ocean-floor topography: mantle-convection currents: *Koninkl. Nederlandse Akad. Wetensch. Proc.*, ser. B, v. 63, no. 4, p. 410-421, 1960.

From the spherical harmonic development of the land and sea-floor topography it is shown that probably during the beginning of the earth's history the spherical harmonic distribution of mantle convection currents corresponded to that to be expected in a viscous fluid mantle, and that during more recent periods the distribution corresponded to an entirely or at least mostly crystalline mantle. These results support the view that the earth is cooling. — D. B. V.

- 187-373. Vogel, A[ndreas]. Laufzeitanomalien von am äusseren Erdkern reflektierten Erdbebenwellen und deren Korrelation zum Schwerkraft- und Nicht-Dipol-Magnetfeld der Erde [Traveltime anomalies of earthquake waves reflected from the outer core and their correlation with the gravitational and nondipole magnetic fields of the earth (with English abstract)]: Zeitschr. Geophysik, v. 26, no. 6, p. 273-275, 1960.

Lucke's criticism of Vogel's paper that attributed anomalies in traveltimes of PcP, ScS, PcS, and ScP waves, geoid undulations, and the nondipole geomagnetic field to irregularities of the core boundary (see Geophys. Abs. 184-442) is answered by assuming convection currents within the core. — D. B. V.

- 187-374. Takeuchi, H[itoshi]. Torsional oscillations of the earth: Royal Astron. Soc. Geophys. Jour., v. 4 (special volume), p. 259-264, 1961.

This is essentially the same paper as previously published in Zisin, ser. 2, v. 13, no. 3, p. 141-149, 1960 (see Geophys. Abs. 185-154). — D. B. V.

ISOTOPE GEOLOGY

- 187-375. Keeling, Charles D. A mechanism for cyclic enrichment of carbon-12 by terrestrial plants: Geochim. et Cosmochim. Acta, v. 24, no. 3/4, p. 299-313, 1961.

A model is described that predicts that variations in relative abundance of C^{12} and C^{13} in terrestrial plants may be due in part to varying degrees of local cycling of CO_2 gas. The model emphasizes the effectiveness of transient departures from a steady state in achieving cyclic enrichment, and predicts that cyclic enrichment should be limited by the maximum concentration of CO_2 occurring near the plants during their diurnal cycle.

A number of predictions related to plant ecology based on this hypothesis may also be used to test the hypothesis: (1) Lower plants and branches of the same plant should show greater enrichment than taller plants and branches, and average enrichment should decline as a plant grows taller; (2) plants in topographic basins should be enriched with respect to those on slopes, those on slopes with respect to those on ridges or summits, and those in the lee of prevailing winds with respect to those in windward locations; (3) a dependence of CO_2 concentration on rainfall, temperature, or season may be reflected in the isotopic ratio; and (4) the fractionation factor should set a lower limit for the enrichment between plants and air which should be reflected in the C^{12}/C^{13} ratio, unless depletion of C^{12} occurs after the absorption of CO_2 by plants. Several of these predictions find experimental support. — D. B. V.

- 187-376. Broecker, W[allace] S., Tucek, C. S., and Olson, E[dwin] A. Radio-carbon analysis of oceanic CO_2 : Internat. Jour. Appl. Radiation and Isotopes, v. 7, p. 1-18, 1959.

Variations in the radiocarbon concentration of oceanic bicarbonate offer clues to large-scale ocean circulation patterns as well as to operation of the terrestrial CO_2 cycle. The process aboard ship for stripping CO_2 gas from acidified ocean water, and the laboratory technique for the purification of the CO_2 and direct measurement of C^{14} activity are described in detail. By mass spectrometrically analyzing the $\text{C}^{13}/\text{C}^{12}$ ratio of the CO_2 assayed for radiocarbon, corrections are made for isotopic fractionation during shipboard processing of the samples. — V. S. N.

Hayakawa, T., Hintenberger, H., and Wänke, H. On the abundances of the helium and neon isotopes produced by cosmic radiation in some iron meteorites. See *Geophys. Abs.* 187-64.

187-377. Craig, Harmon, and Lal, Devendra. The production rate of natural tritium: *Tellus*, v. 13, no. 1, p. 85-105, 1961.

The global mean production rate of natural tritium in the prethermonuclear epoch is calculated from the geochemical inventory to be 0.5 ± 0.3 atoms T/cm^2 sec; this is 3 or 4 times smaller than that of previous calculations. Reasons for the difference are discussed. The predicted production rate is calculated from cosmic ray and nuclear cross section data, using the star production rates in the atmosphere. The predicted mean global tritium production rate during an average solar cycle is found to be 0.25 ± 0.08 atoms T/cm^2 sec, with a variation over an average solar cycle of ± 4.5 percent. These values agree within the uncertainties of the data and calculations; thus there is no observational evidence for accretion of tritium from an extraterrestrial source. — D. B. V.

187-378. Tugarinov, A. I., and Zykov, S. I. Ob izotopnom sostave svintsa rudnykh mestorozhdeniy Kavkaza i Srednei Azii [Isotopic composition of leads from the ore deposits of the Caucasus and central Asia]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull.*, no. 4, p. 66-76, 1961.

Isotopic analyses of lead from Variscan and Alpine ore deposits in the northern Caucasus, Georgia, Armenia, Azerbaijan, the Nuratin Mountains, the Kara-Mazar and Kuramin Mountains, the Turkestan-Alay Mountains, the Tadzhik depression, and central and eastern Kirgiz S. S. R. are reported. Variscan ore deposits of the Caucasus yield lead of fairly uniform isotopic composition (18.00, 15.73, 38.77), but the deposits of central Asia give a broad range of compositions (Variscan: 17.80-18.52, 15.50-16.10, 38.00-38.80; Alpine: 18.19-19.13, 15.66-16.14, 38.31-39.85). The variations in the isotopic composition of the Alpine ores are the result of redeposition of these ores from various earlier sources. — H. F.

187-379. Starik, I. Ye., Sobotovitch, E. V., Lovtsyus, A. V., and Leontyev, V. G. Razdeleniye khimicheskikh form svintsa [Analysis of the chemical forms of lead]: *Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull.*, no. 4, p. 128-135, 1961.

The pyrochemical method of releasing lead from rocks and minerals (see *Geophys. Abs.* 187-9) offers the possibility of determining the chemical form of lead present in small amounts. The sublimation of artificially prepared mixtures of Pb, PbO, PbS, PbSO₄, and PbCl₂ was studied in air, nitrogen, hydrogen, and vacuum. With increasing temperature, PbS, Pb, and

PbSO_4 (as PbO) are liberated in that order in nitrogen, and more PbO sublimes when hydrogen is introduced at $1,200^\circ\text{C}$. A sample of Joachimsthal pitchblende, treated the same way, gave lead progressively richer in radiogenic isotopes. The early lead fractions show a lead already highly radiogenic (in galena), presumably the original lead of the mineralization. The final fractions, about half of the total lead, are heavily enriched in the radiogenic isotopes presumed to have come from metallic Pb disseminated in the uranium mineral. A sample of ferrian thorite, containing 4.7 percent lead, did not show any pronounced fractionation of isotopes. The chemical form of the lead in the thorite is not known. — H. F.

- 187-380. Valentine, James W., and Meade, Robert F. California Pleistocene paleotemperatures: Univ. California Geol. Sci. Pubs., v. 40, no. 1, p. 1-46, 1961.

Estimates of the paleotemperatures of Pleistocene coastal waters off California and northwestern Baja California are made from two lines of evidence: (1) Paleoecology, and (2) oxygen isotope ratios. The range of habitats and temperatures represented by 13 Pleistocene fossil assemblages are inferred from the present distributions and habits of the species. Oxygen isotope paleotemperature estimates were obtained for 43 specimens representing 22 species of Mollusca from the 13 assemblages. The isotopic temperatures fall within the thermal limits of most of the species as inferred from zoogeographic evidence. Paleotemperature estimates from both approaches are in close agreement; they favor times of greater temperature range than today for the period of formation of the Upper Pleistocene terrace deposits and the Lower Pleistocene Lomita marl, and times of cooler temperature than today for the period of the Lower Pleistocene Timms Point silt and San Pedro sand. — V. S. N.

- 187-381. Yeremenko, N. A., and Mekhtiyeva, V. L. Rol' mikroorganizmov protsessakh fraktionirovaniya stabil'nykh izotopov sery [The role of micro-organisms in the processes of fractionation of the stable isotopes of sulfur (with English summary)]: Geokhimiya, no. 2, p. 174-180, 1961.

The fractionation of stable sulfur isotopes during bacterial reduction of sulfates in a closed medium has been investigated experimentally. The results show that the $\text{S}^{32}/\text{S}^{34}$ ratio decreases with time in the H_2S formed in the process. The maximum enrichment of the biogenic H_2S in S^{32} and S^{34} with respect to the amounts in the original sulfate were 11.4 and 6.5 per mil, respectively. The change in the $\text{S}^{32}/\text{S}^{34}$ ratio in biogenic H_2S depends on the isotopic composition of the original sulfate. In sheets of stagnant waters, the formation of H_2S and sulfides is possible not only with heavier but also with lighter sulfur. — D. B. V.

- 187-382. Starik, I. Ye., Starik, F. Ye., and Yelizarova, A. N. Sravnitel'naya vyshchelachivayemost nekotorykh izotopov [Comparative leachability of some isotopes]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 160-165, 1961.

The relative leachability of radium and thorium isotopes from uraninites and of lead isotopes from uraninites and monazites in 5 N, 0.1 N, and 0.01 N HNO_3 is studied, and the results are tabulated. The leachability of Th^{234} , the first decay product of U^{238} , is relatively large, presumably because of the large energy of the decay. The preferential leaching of Th^{228} over Th^{232} with decreasing acid concentration indicates that Th^{228} is in a more mobile

state than Th^{232} , the parent isotope. Common lead has greater leachability than radiogenic lead as shown by Tilton. Pb^{206} and Pb^{207} are leached preferentially over Pb^{208} from monazites, but the opposite is true for uraninites, indicating that uranium and thorium occupy special positions in monazite and uraninite, respectively. — H. F.

- 187-383. Starik, I. Ye., and Lazarev, K. F. Izucheniye adsorbtsionnykh processov, proiskhodyashchikh pri vyshchelachivani [Study of adsorption processes that accompany leaching]: Akad. Nauk SSSR, Kom. Opredeleniyu Absolyut. Vozrasta Geol. Formatsiy Byull., no. 4, p. 136-143, 1961.

The leaching of various isotopes of the uranium and thorium series from monazite with hydrochloric and nitric acids of various concentrations is analyzed. The distribution law describes the process formally. — H. F.

MAGNETIC FIELD OF THE EARTH

- 187-384. Hide, R[aymond], and Roberts, P. H. The origin of the main geomagnetic field, in *Physics and chemistry of the earth*, v. 4: New York, Pergamon Press, p. 27-98, 1961.

Current knowledge concerning the nature and origin of the main geomagnetic field of the earth is reviewed in the following chapters: introduction, description of the geomagnetic field, physical analysis of the irregular field, screening in the mantle, induction theories of the main field, theory of the secular variation, and theory of long period changes. Two appendices complete some of the mathematical calculations. A bibliography of 110 entries is included. — V. S. N.

- 187-385. Hine, A. Some aspects of terrestrial magnetic phenomena: Research Appl. Industry, v. 14, no. 4, p. 143-146, 1961.

A brief historical summary of the development of knowledge concerning terrestrial magnetism is presented, the components of the magnetic field are defined, and the method of taking measurements and the magnetometer used at the Admiralty Compass Observatory are described. The characteristics of both systematic and random changes in the observed values of geomagnetic elements and their relation to solar and ionospheric phenomena are discussed. — V. S. N.

- 187-386. Yukutake, Takesi. Stability and non-steady state of self-exciting dynamos. Pt. 1: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 1-12, 1960.

Study of the time-dependent behavior of Herzenberg's self-exciting dynamo model (two conducting spheres rotating in a large conducting sphere; see Geophys. Abs. 183-417) shows that the steady state cannot be stable for small disturbances. If the magnetic field decreases by chance below a certain value, the coupling torque is weakened and the spheres come to rotate with infinite velocity. If the field is increased, the speed of rotation diminishes. It is anticipated that the magnetic field should reach a maximum and begin to decrease; however, in order to obtain such an oscillatory field, which would explain the reversals of the geomagnetic field indicated by paleomagnetic results, it is necessary to have a closer approximation of the electromagnetic coupling between the two spheres. — D. B. V.

- 187-387. Yukutake, Takesi. Stability and non-steady state of self-exciting dynamos: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 3, p. 437-449, 1960.

The variation with time of the magnetic field and angular velocity are treated mathematically for the case of two conducting spheres rotating in an infinitely extended conductor. Induction equations are approximated by those expanded up to the second time-derivatives of the magnetic field. In some special cases the magnetic field is found to change its polarity with decrease of amplitude. For spheres 500 km in radius rotating 1,100 km apart in the earth's core, the periods of the damping oscillation are about 1.3×10^4 yr. If the effect of the external torque is 10^{-9} erg per sec cm^3 , the induced magnetic field and the surface velocity of the spheres become about 1 gauss and 0.7 cm per sec, respectively. (See also Geophys. Abs. 187-386.)—D. B. V.

- 187-388. Lew, John S. Drift rate in a dipole field: Jour. Geophys. Research, v. 66, no. 9, p. 2681-2685, 1961.

Expressions are found for the drift of charged particles in the field of a magnetic dipole. These give, in the guiding center approximation, the longitude drift rate and drift period of relativistic particles with mirror points at any latitude. The results are applied to trapped electrons and protons in the earth's magnetic field and are adapted for further use in such applications. — Author's abstract

- 187-389. Chapman, Sydney. Scale times and scale lengths of variables: with geomagnetic and ionospheric illustrations: Phys. Soc. [London] Proc., v. 77, pt. 2, p. 424-432, 1961.

The conception of the atmospheric scale height (relating to the proportionate variation of barometric pressure) is generalized to apply to any scalar and vector functions of time and (or) position. Examples are given relative to magnetic fields and the ionosphere. The scale length and scale time here defined enable precision to be given to often used terms such as "slow variation," "distance (or time) "small in relation to the scale of variation" of another quantity. — Author's abstract

- 187-390. de Vuyst, A. Sur les connaissances actuelles du géomagnétisme [On present knowledge of geomagnetism]: Ciel et Terre, v. 76, no. 1-2, p. 1-20, 1960.

This review of the present state of knowledge concerning the magnetic field of the earth discusses the primary field, the residual field and secular variation, paleomagnetism, and the possible origin of the geomagnetic field. — D. B. V.

- Shuleykin, V. V. Experimental test of the hypothesis concerning the nature of magnetic declination. See Geophys. Abs. 187-91.

- Shuleykin, V. V., and Sigachev, N. I. A new test of a hypothesis concerning the nature of magnetic declination. See Geophys. Abs. 187-92.

- 187-391. National Bureau of Standards. Antennas for detecting micropulsations: U.S. Natl. Bur. Standards Tech. News Bull., v. 45, no. 5, p. 83, 1961.

Special-purpose antennas for investigating micropulsations in the earth's magnetic field have been designed and constructed. They will be used to collect data on the behavior of micropulsations and to discover their relationship to unusual manifestations of solar or magnetic activity. Permanent micropulsation installations are being established near Boulder, Colo.; College, Alaska; and Huanacayo, Peru. Additional antennas will equip two portable stations. — V. S. N.

- 187-392. Lipskaya, N. V., Deniskin, N. A., Yegorov, Yu. M., and Shel'ting, V. F. *Statsionarnaya mikrovariatsionnaya stantsiya s fotoelektronnym usileniyem* [Stationary microvariation apparatus with photoelectric amplification]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 42-47, 1960.

A three-component apparatus for continuous recording of geomagnetic field microvariation up to several thousandth of a gamma in amplitude and up to 1 cycle per second frequency is described. This stationary apparatus is based on the magnetostatic principle. The field pickup element is a highly sensitive, low-inertia torsion quartz magnetic balance. This has an oscillating mirror. The beam of light reflected from it is transformed into a photocurrent, which being amplified by a photomultiplier records microvariations on a paper tape at a scale value of 0.005 γ per 1 mm. — A. J. S.

- 187-393. Bullard, E[dward] C., and Mason, R. G. The magnetic field astern of a ship: Deep-Sea Research, v. 8, no. 1, p. 20-27, 1961.

In making measurements of the total force of the earth's magnetic field over the oceans by a magnetometer towed behind a ship, it is necessary to measure the disturbance to the magnetic field produced by the ship. The magnetization of a ship may be divided into a permanent and an induced part. If the induced part is a linear function of the field components and the permanent part is independent of them, the disturbance of the total force by the ship contains a term independent of magnetic heading and terms proportional to the sine and cosine of the heading and of twice the heading, the sine terms being less than a tenth of the cosine terms. The variation with distance astern the ship is similar to that due to a pole near the bow and one near the stern plus a line of vertical dipoles. Results are verified by experiment. The disturbance measured for Discovery II and for Sarsia of less than 10 γ at a distance of 2 ship's lengths astern is believed to hold for most ships. A method for determination of the principal coefficients and their variation with distance is described. — V. S. N.

- 187-394. International Geophysical Year Bulletin (No. 51). Survey of the earth's magnetic field. The world magnetic survey: Am. Geophys. Union Trans., v. 42, no. 3, p. 401-410, 1961.

The projected world magnetic survey will use data gathered since 1955 but will heighten its efforts during the period April 1964-December 1965 when a minimum of solar activity is expected. The nature of the geomagnetic field, types of geomagnetic maps, methods of mapping, and general plans for the survey are outlined. — D. B. V.

- 187-395. International Geophysical Year Bull. (No. 46). Geomagnetic field studies using earth satellites: Am. Geophys. Union Trans., v. 42, no. 2, p. 244-250, 1961.

Analyses of data collected by the proton-precessional magnetometer carried by the Vanguard III (1959 η) satellite are contributing to evaluations of

the accuracy of magnetic charts and computed magnetic fields, determinations of possible discontinuities in the geomagnetic field, and further knowledge of geomagnetic storms and their effects. — D. B. V.

- 187-396. Caner, B., and Loomer, E. I. Record of observations at Victoria magnetic observatory 1957-1958: Dominion Observatory Ottawa Pubs., v. 24, no. 9, p. 223-296, 1961.

Magnetic observations recorded at Victoria Magnetic Observatory, 10 miles north of Victoria, British Columbia, for the period July 1957 through December 1958 are given in monthly tables that include the mean values for horizontal and vertical intensity, declination, and three-hour range indices. A summary table is given for each year to show the diurnal inequalities of the magnetic elements by month. The site of the observatory, instruments used, and types of observations made are described briefly in the introduction. — V. S. N.

- 187-397. Onhauser, A. A., and Onhauser, M. H. Three-hour range indices of magnetic elements—Agincourt and Meanook 1956-57-58: Dominion Observatory Ottawa Pubs., v. 21, no. 4, p. 181-221, 1959.

The three-hour range indices D, H, and Z for Agincourt and Meanook for the years 1956 to 1958 inclusive are given in tables. The K-indices supplied on a routine basis to De Bilt and Göttingen are also included. — V. S. N.

- 187-398. Milliayev, N. A. Magnetic disturbance in the area of operations of drifting stations North Pole 3 and North Pole 4 [translation from Russian]: Problemy Arktiki, no. 5, p. 73-80, 1958; translated by Canada Directorate Sci. Inf. Services, DBR-T339R, 7 p., 1960.

From April 1954 to April 1955 continuous recording of variations of the D, H, and Z components of the geomagnetic field was carried out on drifting stations North Pole 3 and 4. Mobile magnetic variation equipment was used. It was concluded that in years of minimum magnetic activity (1954-55), the mean level of disturbance in the circumpolar region is lower by 1.5 to 2 times than in the zone of maximum magnetic activity ($\phi=68^\circ$); in the formation of the mean level of magnetic disturbance, the principal role is played by the morning and daytime disturbances; the disturbances are 2-3 times greater in the summer than in the winter; night disturbances play an insignificant role in the general level of disturbance and are smallest during the winter with little variation throughout the 24 hr; and the western part is in the postulated second zone of enhanced magnetic activity and is characterized by a daytime disturbance occurring at 13-14 hr universal time. — V. S. N.

- 187-399. Gjellestad, Guro, and Dalseide, Helge. The magnetic station at Dombås ($\phi=62^\circ04'.4N$, $\lambda=9^\circ07'.0E$ Gr). Observations 1958: Norske Inst. Kosmisk Fysikk Pub., no. 49, 17 p., 1960.

Observations made during 1958 at the magnetic observatory at Dombås, Norway, are reported. Tables of absolute hourly mean values in three elements, D, H, and Z, and daily and hourly means for all days and for the 5 international quiet and disturbed days are given. Monthly and annual means for all days and for the 5 international quiet and disturbed days are listed in a separate table, and other tables give the adopted scale and baseline values. — V. S. N.

- 187-400. Selzer, E[douard]. Observations magnétiques faites à l'Observatoire de Chambon-la-Forêt en 1956 [Magnetic observations made

at the Chambon-la-Forêt Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 5-30, 1960.

This tabulates the hourly values of D, H, and Z; the deviation of D, I, H, Z, X, -Y, and F from monthly and annual mean values; the annual hourly values; and the geomagnetic conditions on each day of the year 1956 as observed at Chambon-la-Forêt, France. Annual mean values and secular variations of each component of the total field, calculated from these data, are given in the introduction. — D. B. V.

- 187-401. Noblanc, O. Observations magnétiques faites à l'Observatoire de Nantes en 1956 [Magnetic observations made at the Nantes Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 31-33, 1960.

Deviations of D, H, and Z observed at Nantes, France, from their mean monthly and mean annual hourly values are tabulated, and the mean annual values and secular variations are given for D, I, H, Z, and F. — D. B. V.

- 187-402. Delpeut, Jean. Observations magnétiques faites à l'Observatoire de Ksare (Liban) en 1956 [Magnetic observations made at the Ksara Observatory (Lebanon) in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 35-37, 1960.

Hourly mean monthly and mean annual values of D, H, and Z observed at Ksara in Lebanon in 1956 are tabulated. — D. B. V.

- 187-403. Duclaux, F[rançoise], Bucher, A., Gilbert, D., Will, R[olland], and Oussarof, G. Observations magnétiques faites à l'Observatoire de Tamanrasset en 1956 [Magnetic observations made at the Tamanrasset Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 39-57, 1960.

The hourly values of D, H, and Z observed during 1956 at Tamanrasset, Algeria, are tabulated. Mean annual values of D, I, H, Z, X, Y, and F are given in the introduction. — D. B. V.

- 187-404. O. R. S. T. O. M. Observations magnétiques de l'O. R. S. T. O. M. faites à l'Observatoire de M'Bour en 1956 [Magnetic observations of the O. R. S. T. O. M. made at the M'Bour Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 59-77, 1960.

Hourly values of D, H, and Z during 1956, observed at M'Bour in French West Africa, are tabulated. — D. B. V.

- 187-405. O. R. S. T. O. M. Observations magnétiques de l'O. R. S. T. O. M. faites à l'Observatoire de Bangui en 1956 [Magnetic observations of the O. R. S. T. O. M. made at the Bangui Observatory in 1956]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 79-97, 1960.

Hourly values of D, H, and Z during 1956, observed at Bangui in French Equatorial Africa, are tabulated. — D. B. V.

- 187-406. LeBorgne E[ugène]. Réseau magnétique de répétition de la France Métropolitaine. Troisième série de mesures en ces stations, rapportées à l'époque 1958.0 [Magnetic repeat network of Metropolitan France. Third series of measurements at these stations, re-

duced to epoch 1958.0]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 99-115, 1960.

The results of a third series of measurements of D, H, and Z at the 16 stations of the magnetic repeat network in France and Corsica, reduced to epoch 1958.0 and referred to Chambon-la-Forêt standards, are tabulated. Values of I and F deduced from the corresponding H and Z measurements are also given. Secular variations of D, H, Z, I, and F are shown on maps and discussed. — D. B. V.

- 187-407. Cecchini, A[ndrè], Jobert, N[elly], LeBorgne, E[ugène], and Selzer, E[douard]. Nouveau reseau magnétique de la Corse [New magnetic network of Corsica]: *Inst. Physique du Globe Paris Annales*, v. 30, p. 125-156, 1960.

A revision of the local geomagnetic network of Corsica was undertaken in 1953. A Chasselon magnetic theodolite, and 2 QHM and 2 BMZ magnetometers were used. Instrumental calibration, methods of operation, and reduction of the results are discussed briefly. The values of D, H, Z, I, X, -Y, and F are listed for the 106 stations of the network, and each station is described. Results are presented in the form of maps of D, H, Z, and I, reduced to epoch 1953.0. Finally, secular variations of D, H, Z, and I since 1924 are tabulated for 19 stations. — D. B. V.

- 187-408. MacDowall, J., and Blackie, A. Geomagnetic observations, in *The Royal Society International Geophysical Year Antarctic Expedition Halley Bay, Coats Land, Falkland Islands Dependencies 1955-1959*, v. 1: London, The Royal Society, p. 61-224, M 1-181, 1960.

Geomagnetic observations made at Halley Bay, Antarctica, by scientists of the Royal Society of London for the International Geophysical Year, 1957-58, are reported. The following are discussed: site of the nonmagnetic hut; instruments for continuous recording; absolute measurements; allocation of base lines; insensitive recorder H, D, and Z scale values and base lines; the diurnal variation of the geomagnetic elements; the incidence of geomagnetic activity; geomagnetic activity as shown by analysis of K-indices; diurnal variations indicated by the Q-index of activity; frequency distribution of absolute daily range R; the diurnal distribution of the times of incidence of the daily maximum and minimum values of the geomagnetic field; the daily Ck-index of local geomagnetic activity; local selection of days at various levels of activity; variation of the geomagnetic elements, vector field changes; data tabulated; and magnetograms reproduced. The report includes 186 tables, 45 figures, and 181 pages of magnetograms. — V. S. N.

- 187-409. Kakinuma, Seiichi, and Muraishi, Yukihiro. Report on geomagnetic total force observation in the fourth Japanese Antarctic research expedition [in Japanese with English abstract]: *Antarctic Rec.*, no. 11, p. 200-203, 1961.

The results of geomagnetic total force observations made between Cape Town and the Antarctic Ocean by the 4th Japanese Antarctic Expedition (1959-60) are reported, and comparisons are made with results from the second and third expeditions. These results are illustrated. — V. S. N.

- 187-410. Shuleykin, V. V. Nekotoryye osobennosti vekovykh izmeneniy magnitnogo polya nad okeanom [Some features of the secular variation of the magnetic field over the oceans]: *Akad. Nauk SSSR Doklady*, v. 137, no. 4, p. 848-851, 1961.

Examination of the course of secular magnetic variation suggests that there is a genetic connection between Bullard's drifting convection nuclei and the main geomagnetic field, whose axis coincides with the axis of rotation of the earth. If these "eddies" of the electromagnetic field can interact with the poorly conducting solid mantle to cause the drift of the convection nuclei, they should exert a much greater effect on the well conducting ocean waters. Changes in declination on passing from continents to oceans, shown on a sketch map, are related to telluric current eddies produced when the nuclei pass from land to water. It is possible that interaction of the nuclei with the waters of individual seas produces constant current components on which are superposed eddy currents induced in the sea at the time of magnetic storms. — D. B. V.

- 187-411. Nagata, Takeshi [Takesi]. Geomagnetic secular variation over and near the Antarctic continent [with Japanese abstract]: Antarctic Rec., no. 11, p. 217-224, 1961.

The results of study of geomagnetic secular variation in the vicinity of the Antarctic Continent by the Japanese Antarctic Research Expeditions indicate that variations in the geomagnetic field at Syowa Station and the neighboring areas are extremely large. The average secular variations at Syowa Station for the period of 1957-60 (in γ per year), were as follows: $X=-79$, $Y=-40$, $Z=+181$, $D=-14.1$ (min per year), and $H_2=-28$. Differences between measurements in Lützow-Holm Bay in 1956-57 and those of Vestine's magnetic chart compiled in 1945 amount to about $+5 \times 10^3$ for Z , -2×10^3 for H , and about one degree for D . The reliability of observations of variations for the area of the Antarctic continent as recorded by permanent stations at Macquarie Island and Orcadas del Sur, several Argentinian stations, and a group of temporary stations established for the International Geophysical Year are discussed. Comparison of the southern with the northern hemisphere shows that secular variation in the geomagnetic field is much more active in the southern than in the northern hemisphere with respect to both the number of focuses and their intensity. It is suggested that the origin of two neighboring focuses near the coast of East Antarctica maybe attributed to a pair of radial magnetic dipoles on the earth's core; the upward magnetic dipole would have about 3.5×10^{22} emu per yr as the rate of change in moment, while the downward dipole, 15° away would have about 2.3×10^{22} . — V. S. N.

- 187-412. Mansurov, S. M. Vekovyye variatsii geomagnitnogo polya Vostochnoy Antarktidi [Secular variation of the geomagnetic field in East Antarctica]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 48-52, 1960.

Secular variations in the earth's magnetic field in the region of the U.S.S.R. Antarctic magnetic observatories Oasis (18 average monthly observations), Mirnyy (44 observations), Pionerskaya (17 observations), and Vostok (26 observations) are determined for 1957-59. Attention is drawn to the two-year periodic variation of the H component and the correspondence of this period to the synodic revolution period of Mars. It is also noted that the observed amplitude of δH long-period variations during 1957-59 was three times greater than the same variation according to earlier data. — A. J. S.

- 187-413. Ellis, G. R. A. Geomagnetic micropulsations: Australian Jour. Physics, v. 13, no. 4, p. 625-632, 1960.

The results of simultaneous observations of geomagnetic micropulsations at three places ranging from 28° S. to 51° S. geomagnetic latitude during the period September 1959 to April 1960 are described. There is no observable

change in the micropulsation period with latitude although there is a monotonic increase in amplitude with latitude for all periods between 10 and 100 sec. These results are discussed in the light of existing theories of the geomagnetic field. — D. B. V.

- 187-414. Campbell, Wallace H. Magnetic field micropulsations and electron bremsstrahlung: Jour. Geophys. Research, v. 66, no. 10, p. 3599-3600, 1961.

Observations of enhanced magnetic micropulsation activity in the auroral zone near College, Alaska, simultaneous with increases in intensity of bremsstrahlung from energetic electrons, are reported. — D. B. V.

- 187-415. Oshima, H. Pc-type pulsations and geomagnetic disturbances [with Japanese abstract]: Kakioka Magnetic Observatory Mem., v. 9, no. 2, p. 1-13, 1960.

To analyze the relation between the pc-type pulsations and other phenomena an attempt is made to express quantitatively by an index the activity of pc-type pulsations. A P-index on a scale of 10 grades determined by the amplitude of the pulsation in each 5 min interval is presented and discussed. It is anticipated that an index determined by amplitude alone will express with accuracy the general behavior of pc-type pulsations for the narrow range of periods of 10-40 sec with mushroom growth of occurrence-frequency at about 20 sec. The P-index is utilized in this paper to study the relation between pc-type pulsations and geomagnetic disturbances and some results are described. It is concluded that pc-type pulsations are generally active in the geomagnetically disturbed period. Even at times of no geomagnetic disturbances, the great and typical diurnal variations of ΣP appear; these also appear in times of rather high geomagnetic activity. It was found that ΣP increases suddenly at the time of storm commencement, but that this increase is not due to an increase in its typical diurnal variations. — V. S. N.

- 187-416. Saito, Takao. Period analysis of geomagnetic pulsations by a sonagraph method: Tohoku Univ. Sci. Repts., ser. 5, v. 12, no. 2, p. 105-113, 1960.

An attempt at period analysis of geomagnetic pulsations by means of a sonagraph is described and illustrated. Induction magnetograms obtained at the Onagawa Magnetic Observatory in Japan were reprinted on film and reproduced photomechanically as a sound wave that was then analyzed for period, amplitude, and time by a sonagraph. A daily variation of period, amplitude and other characteristics revealed in the pt, pc, storm time pulsation, and pulsation accompanying ssc is interpreted in terms of differences in apparent heights of hydromagnetic barriers between the sunlit and night hemispheres. — D. B. V.

- 187-417. Nagata, Takesi, and Kokubun, Susumu. Relation between geomagnetic disturbances in the northern and southern polar regions [with Japanese abstract]: Antarctic Rec., no. 11, p. 204-216, 1961.

This is virtually the same paper as previously published in Rept. Ionosphere and Space Research Japan, v. 14, no. 3, p. 273-290, 1960 (see Geophys. Abs. 186-495). — V. S. N.

- 187-418. Yanagihara, K[azuo]. Geomagnetic pulsations in middle latitudes—morphology and its interpretation [with Japanese abstract]: Kakioka Magnetic Observatory Mem., v. 9, no. 2, p. 15-74, 1960.

Data from observations during the International Geophysical Year are used to classify, characterize, and interpret the geomagnetic pulsations observed at middle latitudes. Pt and pc pulsations are the most prominent and typical on the records, although to distinguish them careful consideration must be made of the frequency response of the instruments used in making the observations. Particular attention is given to the difference in character between disturbance-type and calm-type pulsations in their diurnal, annual, or 11-year variations. Behaviors of the variations of activity are found to vary according to the relative efficiency of the primary agency or terrestrial effect near the earth, especially in the variation of the disturbance-type pulsation. The annual variation of occurrence frequency of disturbance-type pt or pc shows equinoctial maximums, whereas the calm-type pt or pc has maximum activity in winter or summer. — V. S. N.

- 187-419. Ol', A. I. Sinopticheskiye karty magnitnoy vozmushchennosti v Arktike [Synoptic charts of magnetic disturbances in the Arctic]: Akad. Nauk SSSR, 3d Sess., IGY Program, no. 4, Geomagnetic disturbances, p. 22-29, 1960.

Synoptic charts of magnetic disturbances r_H^Y made from the data of high latitude geomagnetic observations during 1957-58 are discussed. Two-hour charts and a few examples of successive hourly charts of magnetic disturbances are given. A considerable variation in disturbance distribution with universal time was found. Characteristic of these distributions are their focal, nonzonal concentration. The disturbances are found to change their distribution disorderly from hour to hour, while the focuses of the disturbances remained fixed for several hours at the same locality. — A. J. S.

- 187-420. Zhigalov, L. N. O nekotorykh osobennostyakh variatsiy vertikal'noy sostavlyayushchey magnitnogo polya Zemli v Severnom Ledovitom okeane [On some specific features in variations of the vertical component of the earth's magnetic field in the Arctic Ocean]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 30-34, 1960.

A study of geomagnetic variations obtained by the U. S. S. R. SP-6 drifting station in the Arctic in 1957-58 and by U. S. S. R. high latitude Arctic geomagnetic observatories has led to the conclusion that the character of variations in the vertical component of the earth's magnetic field depends on the depth of the ocean where the reading is taken. The amplitude of the short-period part of the variations (5-10 γ) was found to drop sharply with increases in ocean depth and to disappear completely where the depth is greater than 2,500-3,000 m. — A. J. S.

- 187-421. Angenheister, Gustav [H.], and Consbruch, Claus von. Pulsationen des erdmagnetischen Feldes in Göttingen von 1953-1958 [Pulsation of the magnetic field of the earth in Göttingen for 1953-1958 (with English summary)]: Zeitschr. Geophysik, v. 27, no. 1, p. 3-12, 1961.

Records of the H component obtained at Göttingen, Germany, from 1953 to 1958 with a Grenet-type induction magnetograph are analyzed. The index P_z ("Pulsationszahl") is introduced, defined as $P_z(h, d, m, T) = n \cdot a / (3,600/T)$, where n is the number of cycles, a is the mean amplitude of an octave interval with the central period T in the hour h of the day d of the month m ; the octaves are period ranges $T = 7.5-15, 15-30, 30-60, 60-120, 120-240, 240-480$ sec. The data are divided into three classes: disturbed (D), moderate (M), and quiet

(Q) days. The daily variation of the values of \bar{P}_Z (the values divided by the mean of the day), τ_Z (the smoothed values), and $2\tau_Z$ (the doubly smoothed values) are plotted against universal time. — D. B. V.

- 187-422. Honda, Hirokichi; Kato, Yoshio; and Yamamoto, Giichi, eds. Geomagnetic rapid variations observed at the Onagawa Magnetic Observatory during the International Geophysical Year, Pt. II: Tohoku Univ. Sci. Repts., ser. 5, v. 12 supp., p. 1-75, 1961.

The geomagnetic rapid variations observed at the Onagawa Magnetic Observatory during the International Geophysical Year, January 1 to December 31, 1958 are reported. Storm sudden commencement (ssc or ssc*), sudden impulse (si), geomagnetic bay (b, bp, bs, or bps), and solar flare effect (sfe) were observed by the normal and highly sensitive rapid run magnetometers; the results are tabulated. Tabulated results are also given for geomagnetic rapid pulsation (pc and pt) observed with the induction and highly sensitive rapid run magnetometers; the original induction magnetometer records for ssc, si, pt, and pc are reproduced in plates. — V. S. N.

- 187-423. Ponomarev, Ye. A. O prirode beregovogo effecta [On the nature of the coast effect]: Akad. Nauk SSSR, 3d Sess. IGY Program no. 4. Geomagnetic disturbances, p. 35-41, 1960.

The geomagnetic coast effect reported by Mansurov (see Geophys. Abs. 187-412) in the region of the Mirny Observatory in Antarctica is considered to be a skin-effect, because the electrical conductivity of sea water is at least 4 orders greater than that of ice and crystalline rock, which constitute the shore and the submarine slope. An attempt is made to explain the sudden increase in relative values of variations of the magnetic field along the coast of Antarctica. An analysis of the problem and its solution are given. — A. J. S.

- 187-424. Rikitake, T[suneji]. The effect of the ocean on rapid geomagnetic changes: Royal Astron. Soc. Geophys. Jour., v. 5, no. 1, p. 1-15, 1961.

Electromagnetic induction in a conductor covered by a conducting sheet has been studied with the aid of two-dimensional experiments and mathematical theory. Application of the results to the effect of the ocean on rapid geomagnetic variations shows that the previous estimate of the ocean effect, based on induction in a single sheet, is too large.

Cox's explanation (unpublished) of the anomalous geomagnetic variations of Japan by the effect of the ocean at its margin is criticized. Rikitake believes the anomaly is caused by induced currents deep beneath Japan (see Geophys. Abs. 180-266). — D. B. V.

- 187-425. Helliwell, R. A. Exospheric electron density variations deduced from whistlers [with French and Russian abstracts]: Annales Géophysique, v. 17, no. 1, p. 76-81, 1961.

A new model based on whistler dispersion data from the International Geophysical Year shows that the electron density of the equatorial exosphere is approximately proportional to the earth's magnetic field out to five earth radii. The density decreases significantly faster with height than predicted theoretically by Dungey. An annual variation in electron density in which the December value is nearly twice the June value has been discovered. The variation is much larger than can be explained by the annual variation of the earth-sun distance, and it may be intimately connected with the mechanism of solar control of the outer ionosphere. — V. S. N.

- 187-426. Vestine, E. H. Geomagnetism in relation to aeronomy: *Annales Géophysique*, v. 17, no. 2, p. 181-194, 1961.

The geomagnetic field and its time fluctuations, which are of interest to aeronomy, are described. The theories that have been brought forward to explain these fluctuations are reviewed. The role of upper air winds in producing the solar and lunar daily magnetic variations, and that of charged energetic particles in causing geomagnetic disturbance are indicated. The response of geomagnetically trapped radiation in the Van Allen belts and adjacent regions to geomagnetic field changes is discussed. The use of integral invariants in predicting certain auroral effects and especially the explanation of auroral isochasms is also reviewed. Finally, mention is made of the early findings of rocket probes penetrating nearby space. — Author's abstract

- 187-427. Duffus, H. J. A connexion between Pc and the F region: *Nature*, v. 188, no. 4752, p. 719-721, 1960.

Analysis of International Geophysical Year data on geomagnetic micropulsations suggests that there might be a worldwide relationship between Pc and ionospheric electron density that is obscured by local effects. As yet there are only enough data to suggest that the diurnal variation of Pc is inversely related to the diurnal variation of the true electron density at 280 km. It is necessary to postulate a source of Pc in the outer atmosphere that is stronger on the sunlit side of the earth. The present results do not exclude the possibility that localized hydromagnetic resonance in the upper F region is the source of some Pc disturbances. — D. B. V.

- 187-428. Lock, C. M., and Stevens, P. J. Connexion between micropulsations and the ionosphere: *Nature*, v. 191, no. 4788, p. 584-585, 1961.

Results of simultaneous magnetometer observations at Christchurch, England, and Ascension Island, close to the geomagnetic equator, confirm Duffus' conclusions (see also Geophys. Abs. 187-427) that the low atmosphere has a modulating control over Pc and also show that this control varies markedly with latitude, in contrast to Pt. The problem is to explain why Pt are nighttime phenomena and are coherent over a great latitude range, being of greater amplitude at high latitude, while Pc are recorded in the daytime and vary with latitude, both classes of pulsation being linked with the ionosphere.

It is suggested that Pt may be oscillations of the outer atmosphere which are coupled with the ionospheric duct at the auroral belt, being propagated only in the low-attenuation nighttime state of the ionosphere, while Pc may have a much more local and resonant transmission system, still originating in an outer atmosphere oscillatory mode. It is possible that part of their oscillatory content is inherent in the arriving corpuscular stream. — D. B. V.

- 187-429. Sugiura, Masahisa. Some evidence of hydromagnetic waves in the earth's magnetic field: *Phys. Rev. Letters*, v. 6, no. 6, p. 255-257, 1961.

Observations of damped oscillations at College, Alaska, may be considered as evidence of hydromagnetic waves propagated to the earth from its outer atmosphere. The waves are nearly elliptically polarized, suggesting that they are generated at an altitude of several earth radii and propagated along the lines of magnetic force. They are mostly confined to the auroral zones and occur simultaneously in the northern and southern hemispheres. They are probably generated by a sudden motion of the gas or by an electric field suddenly imposed on the gas. — D. B. V.

- 187-430. Campbell, Wallace H. Natural electromagnetic energy below the ELF range: U.S. Natl. Bur. Standards Jour. Research, v. 64D, no. 4, p. 409-411, 1960.

The transition of natural signals from sferics slowtails to geomagnetic micropulsations was observed between 2.0 and 0.2 cycles per second. Micropulsations with periods of 5-30 sec have characteristics which closely relate to solar terrestrial disturbance phenomena. The low latitude diurnal amplitude variation has maximums at 0945 and 1000 local meridian time. Similar groups of oscillations appear in Alaska and California. Simultaneous pulsation of λ 3,914 aurora and magnetic field micropulsations has been observed in Alaska. — Author's abstract

- 187-431. Tamao, Tsutomu. Deviations of geomagnetic field and hydromagnetic characteristics in the outer exosphere: Tôhoku Univ. Sci. Repts., ser. 5, v. 12, no. 3, p. 159-168, 1961.

The mechanism of the current system responsible for deviations of the geomagnetic field from the dipole field, observed in the exosphere at 5-7 earth radii by Sonnett and others (see Geophys. Abs. 186-480), is discussed. The diamagnetic effect of the thermal plasma is insufficient to explain the deviations; trapping of diffused solar particles having a velocity of 10^8 cm per sec in the weakly disturbed region is required.

Since the contribution from the component of gas kinetic pressure perpendicular to the direction of the field is partly canceled by the diamagnetic effect of the trapping particles, the net contribution from the pressure anisotropy is strengthened in the formation of current. It may be that the source of the observed deviations of the field is a ring current resulting from protons of several tens of Kev diffused into and accelerated within the region of 7-12 earth radii. — D. B. V.

- 187-432. Yoshino, Takeo. Observation of aurora noise at Syowa Base [with Japanese abstract]: Antarctic Rec., no. 11, p. 179-183, 1961.

An investigation of the property of radio waves radiating from the highly ionized gas in the troposphere when occupied by an aurora was carried out at Syowa Base in the Antarctic to find the explanation of the mechanism of aurora luminescence and to analyze the phenomenon of troposphere caused by proton beams from the sun. The radio waves were observed mainly at 3,000 megacycles and occasionally at 60 megacycles. Observations continued from March 15, 1959 through January 15, 1960. To analyze the results a simultaneous comparison is being made with data from terrestrial magnetism, earth currents, and strength and optical spectrum of the aurora and ionosphere. This has been completed for May 23, 1959, and the results are illustrated in a graph. — V. S. N.

- 187-433. Wakai, Noboru. Seasonal variation of f_oF2 and abnormal ionization in F region at Syowa Base in Antarctica [with Japanese abstract]: Antarctic Rec., no. 11, p. 195-199, 1961.

The results of analyses of vertical sounding of the ionosphere at Syowa Base (lat 69°00' S., long 39°35' E.) for the period February 1959 through January 1960 are reported. The correspondence of monthly median values of f_oF2 between Arctic and Antarctic regions and the abnormal ionization in the F region are discussed. The diurnal variations of the monthly median values of f_oF2 in each month show a systematic delay in the appearance of the maximum value of f_oF2 after 12 noon. A comparison of data from stations in both the Arctic

and Antarctic auroral zones shows a fixed delay time to be consistent at each station. It is observed that the delay time of E and F1 layers have a simple correlation with the zenith angle of the sun, but that of the F2 layer has a complex correlation with the solar zenith angle and the geomagnetic longitude.

It is proposed that the abnormal ionization in the F region should be listed in the table of ionospheric characteristics in high latitude. These abnormal traces, which are neither normal nor oblique and transient, often occur in the ionograms observed at Syowa Base; these so-called Fs traces generally appear just before or after the time when Es ionization or polar black-out occurs. — V. S. N.

- 187-434. Davis, T. Neil. An investigation of the morphology of the auroral displays of 1957-58: Alaska Univ. Geophys. Inst. Sci. Rept., no. 1, 107 p., 1961.

The results of a study of auroral morphology based on the all-sky camera records obtained during the International Geophysical Year from a close-spaced network of stations in Alaska and from an array of stations extending from Chateau, Mont., across Canada to Thule, Greenland, are reported. The aspects studied include the time and latitude dependency of the incidence, azimuthal alinement, and direction of horizontal motion of auroral forms, and the relation of these aspects to magnetic disturbance. Detailed analyses of individual auroral displays and the concurrent magnetic disturbance indicate detailed association of the alinement and direction of motion of auroral forms with the density and direction of ionospheric currents. The ionospheric current flow is generally parallel to the alinement of auroral forms and is opposite in direction to the observed motion within the forms. — V. S. N.

- 187-435. Afanas'yeva, V. I., and Kalinin, Yu. D. Ochen' bol'shiye i bol'shiye geomagnitnyye buri i nekotoryye voprosy ikh teorii [Very great and great geomagnetic storms and certain problems of their theory]: Akad. Nauk SSSR, 3d Sess. IGY Program, no. 4, Geomagnetic disturbances, p. 5-14, 1960.

The theory of geomagnetic storms is discussed on a basis of the data given in the geomagnetic storms catalogues for 1878-1959. The storms are considered to be due to turbulence caused by corpuscular solar emission streaming through interplanetary plasma. By applying the principles of magnetohydrodynamics to the turbulence of the plasma, it was found that the magnetic field around the earth can be amplified by 600 times or more. A 30-year period in the duration of moderate magnetic storms was detected. A periodic variation in density of the interplanetary medium is considered as a contributing agent, causing a displacement of the maximum in the number of storms in the 11-year cycle. — A. J. S.

- 187-436. Akasofu, S-I [Syun-Ichi], and Chapman, S[Sydney]. The sudden commencement of geomagnetic storms: Vrania, no. 250, 35 p., 1960; reprinted in Alaska Univ. Geophys. Inst. Contrib., ser. B, no. 54, 1961.

Many magnetic storms begin suddenly and simultaneously all over the earth. These sudden commencements are denoted by Sc; different local types that may be distinguished by the sign and order of sudden changes of horizontal intensity are denoted by Sc(+), Sc(-+), Sc(++), Sc(-), and Sc(++). The known statistical facts are summarized for the daily and yearly variations of frequency and amplitude of Sc's of different types, and for Si's (the sudden im-

pulses shown sometimes by magnetographs) that are not followed by any easily recognizable storm. The conventional current diagrams for the external primary Sc field are analyzed in two parts, one part being of type Sc(+), the other corresponding to a current system that is strongest in polar regions and probably generated there. The combination of the two parts, in different proportions at different places, explains the production of different local types of Sc. Theoretical explanations of Sc are discussed. The Sc(+) part of the field is attributed to field changes produced by sudden retardation of a stream of ionized solar gas impinging on the earth's field at a distance of a few earth radii. The polar current system is thought to be energized by entry of solar particles (or alternatively shock waves) into the polar regions. The Sc(+) field change appears to be transmitted to the earth's surface by hydromagnetic waves. A bibliography of 92 references is included. — V. S. N.

- 187-437. Akasofu, Syun-Ichi, and Chapman, Sydney. A study of magnetic storms and auroras; Alaska Univ. Geophys. Inst. Sci. Rept., no. 7, 209 p., 1961.

New notations for magnetic disturbance fields are proposed, based on the theoretical consideration of the electric current systems by which they are produced. A typical magnetic storm begins when the onrush of the front of the solar gas is halted by the earth's magnetic field. This effect (DCF field) is observed as a sudden increase of the horizontal component of the earth's field (ssc). The change of the field during ssc is often complex; such complexity is ascribed to a current system generated in the polar ionosphere (DP current). Changes of electromagnetic conditions in the polar regions are communicated, without delay, to lower equatorial latitudes, even to equatorial regions. The equatorial jet is affected by such a change and produces the abnormal enhancement of ssc along the magnetic dip equator.

Extensive analysis of several magnetic storms indicates that capture of the solar particles in the outer geomagnetic field occurs when irregularities embedded in the solar stream impinge on the earth. The motions and resulting currents and magnetic fields of such "trapped" solar particles are studied in detail for a special model. It is proposed that during the storm a transient "storm-time" belt or ring current appears well outside the outer radiation belt at about 6 earth radii. When the ring current is appreciably enhanced, the earth's magnetic field is reversed in limited regions. This involves the formation of neutral lines of two types one of which is connected with the auroral ionosphere by lines of force and could be the source of particles that produce the aurora polaris. Several typical DP substorms resulting from the appearance of the auroral electrojet, when the aurora changes from the diffuse to the active form, are studied. — V. S. N.

- 187-438. Chapman, S[Sydney], and Kendall, P. C. An idealized problem of plasma dynamics that bears on geomagnetic storm theory: oblique projection: Jour. Atmos. Terrest. Physics, v. 22, no. 2, p. 142-156, 1961.

An exact solution is given for the problem of a cylindrical neutral sheet of plasma with given initial surface density of angular momentum which advances into a unidirectional magnetic field whose intensity at distance r from the axis varies as $1/r^3$. The initial densities of charge (\pm) and of angular momentum determine the particle orbits and the distance of closest approach of the sheet. This problem has a bearing on the efficiency of the geomagnetic field as a scatterer of particles in an incident solar stream. Some of the particles will be turned back toward the sun. — D. B. V.

- 187-439. Dessler, A. J., Hanson, W. B., and Parker, E. N. Formation of the geomagnetic storm main-phase ring current: *Jour. Geophys. Research*, v. 66, no. 11, p. 3631-3637, 1961.

It is suggested that hydromagnetic waves generated by the impact of solar plasma on the geomagnetic field may form shock waves in the magnetosphere, thus providing a mechanism for establishing the diamagnetic main-phase ring current. If so, the decay time of the ring current should be less during years of sunspot minimum than during sunspot maximum. — D. B. V.

- 187-440. MacDonald, Gordon J. F. Spectrum of hydromagnetic waves in the exosphere: *Jour. Geophys. Research*, v. 66, no. 11, p. 3639-3670, 1961.

A disturbance in the exosphere generates waves in three partially separable modes. The modes are described by considering the vorticity about a line of force, the two-dimensional divergences of velocity in the plane perpendicular to the line of force, and the component of velocity along the line of force. The propagation of vorticity is one-dimensional and there is no geometrical attenuation. It is suggested that this mode is associated with the sudden commencement of a magnetic storm. High-frequency micropulsations may also be associated with vorticity mode propagation. — D. B. V.

- 187-441. Bell, Barbara, Major flares and geomagnetic activity: *Smithsonian Contrib. to Astrophysics*, v. 5, no. 7, p. 69-83, 1961.

Relations between geomagnetic activity and major (importance $\geq 2+$) solar flares are studied with primary attention to magnetic type and location of the flaring sunspot group. The data cover the years 1937-59 and include 580 observed major flares. It is found that a major flare occurring in association with a magnetically complex (γ or $\beta\gamma$) sunspot group is much more likely to be followed by a major geomagnetic storm than is a similar flare in a unipolar (α) or bipolar (β) group. Great-storm flares show the expected concentration toward the central regions of the solar disc, and also an unexpected concentration in the northern solar hemisphere. In the 23 years studied, northern spot groups produced 62 percent of all observed major flares, and 86 percent of those followed within 3 days by a great geomagnetic storm. This north predominance of great-storm flares appears about equally in each of the three sunspot maximum covered and is apparently not related to the 11-year or 12-year solar cycles. — Author's abstract

- 187-442. Chapman, Sydney. Sun storms and the earth: The aurora polaris and the space around the earth: *Am. Scientist*, v. 49, no. 3, p. 249-284, 1961.

A new theory for the origin of the aurora polaris developed over the past few years by Chapman and Akasofu (see *Geophys. Abs.* 181, 354, 185-432, 187-437) is reviewed. A general description is given of the form and location of the aurora in both the Northern and Southern Hemispheres followed by a discussion of the intimate connection between the aurora and the magnetic field of the earth and between the aurora and the sunspot cycle, the height of auroras, their geographical location, the nature of auroral light, solar streams and clouds, and the development of auroral theory beginning with Birkeland's. The earth's magnetic shield and DCF magnetic disturbance, the capture of some solar gas by the geomagnetic field, and its behavior as a prisoner and as the source of the small minority of particles that travel down the lines of force into our atmosphere are discussed. — V. S. N.

- 187-443. Dessler, A. J. The stability of the interface between the solar wind and the geomagnetic field: *Jour. Geophys. Research*, v. 66, no. 10, p. 3587-3590, 1961.
- Coleman, P. J., Jr., and Sonett, C. P. Note on hydromagnetic propagation and geomagnetic field stability: *Jour. Geophys. Research*, v. 66, no. 10, p. 3591-3592, 1961.

Dessler presents evidence to show that the interface between the solar wind and the geomagnetic field is stable in a gross sense. Those world-wide fluctuations that are transmitted from the interface to the earth's surface by hydromagnetic waves must then be due solely to energy-density fluctuations in the solar wind. If so, theories of aurora, Van Allen radiation, or magnetic storms that utilize the concept of turbulent solar injection in an important way must be reexamined.

Coleman and Sonett point out that Dessler's use of surface observations of magnetic activity to estimate the conditions at great distances above the surface is not valid in the light of available data. Hydromagnetic disturbances as great as 100% have been observed in the distant geomagnetic field by space probes, with no associated effects observed on the ground. — D. B. V.

- 187-444. Ondoh, T. A possible explanation of sc^* observed at high geomagnetic latitudes: *Jour. Atmos. Terrest. Physics*, v. 21, no. 4, p. 284-287, 1961.

It is deduced that the preliminary reverse impulse of sc^* is generated by a dynamo action of ionization due to high speed charged particles (10^4 km/s) impinging on the high latitude ionosphere or an initial diamagnetic effect due to such charged particles spiraling about the geomagnetic lines of force, and that hydromagnetic waves propagating along the geomagnetic line of force from the geomagnetic equatorial plane to the earth's surface cause the main impulse of sc^* at high latitudes. Other hydromagnetic waves propagating obliquely or perpendicular to the geomagnetic lines of force cause the sudden increase of the geomagnetic field at low latitudes.

This model can explain the observation that sudden commencements have been registered earlier at high latitudes than at low latitudes and that the preliminary reverse impulse has preceded the main sc^* impulse by one or two minutes. The model requires that ordinary sc at low latitudes should occur several tens of seconds earlier than the main impulse of sc^* at high latitudes. Distortion of the geomagnetic field by impact of solar plasma has not been taken into account in these considerations. — D. B. V.

- 187-445. Yoshimatsu, T[akasaburo]. Universal time daily inequality of the time of maximum depression of ssc in storm-time [with Japanese abstract]: *Kakioka Magnetic Observatory Mem.*, v. 9, no. 2, p. 75-81, 1960.

One of the results of a study of the time characteristics of geomagnetic storms observed at the Kakioka Magnetic Observatory, Kakioka, Japan, during the period 1924 to 1959, is discussed. It was found that the time of maximum depression of the horizontal intensity of ssc measured during a geomagnetic storm undergoes a universal diurnal inequality; a predominant maximum and minimum occur near 14 hr and 8 hr, and a minor maximum and minimum occur at 20 hr and 17 hr. This characteristic was checked for each of three groups of storms, classified on the basis of size, and was further confirmed by comparison with results from observatories at Tucson, San Juan, Abinger, Wingst, and Huancayo. — V. S. N.

- 187-446. Yasuhara, M., and Maeda, H[iroshi]. Geomagnetic crochet of 15 November 1960: Jour. Atmos. Terrest. Physics, v. 21, no. 4, p. 289-293, 1961.

The unusually large geomagnetic bay of November 15, 1960 is described. The pattern of ionospheric currents necessary to produce the horizontal component of the bay is shown on a map. The evidence favors the conclusion that there must have been considerable penetration of solar X-rays into the D-region at the time of maximum development of the solar flare; this played an important role in the occurrence of sudden ionospheric disturbance and the large geomagnetic bay. — D. B. V.

- 187-447. Niblett, E. R. Geomagnetic variations between November 12 and November 16, 1960: Canadian Jour. Physics, v. 39, no. 4, p. 619-622, 1961; also in Dominion Observatory Ottawa Contrib., v. 5, no. 8, 6 p., 1961.

Exceptionally large geomagnetic disturbances have been reported from observatories in many parts of the world during the interval November 12-16, 1960. Records of these disturbances at the Canadian stations at Victoria, Agincourt, Meanook, Baker Lake, and Resolute are described briefly. — D. B. V.

- 187-448. Stavrou, A[ngelos]. The Magnetic Observatory of Pendeli (Athens, Greece): Geofisica Pura e Appl., v. 46, p. 95-109, 1960.

The new Pendeli Magnetic Observatory near Athens began operating in April 1958. Its location, foundation, physical plant, and instrumentation are described. The H and Z variometers are of the magnetic balance type; a fiber suspension declinometer is used for D. Absolute measurements are made with an Askania field magnetic theodolite; absolute declination is determined in a fiber declinometer, and absolute H is measured both by the classic Gauss method and, since 1959, by means of a QHM magnetometer. Inclination is measured by an earth inductor forming part of the magnetic theodolite. — D. B. V.

MAGNETIC PROPERTIES AND PALEOMAGNETISM

- 187-449. Sholpo, L. Ye. Sravnitel'nyye issledovaniya nekotorykh magnitnykh svoystv normal'noi obratno namagnichennykh effuzivnykh bazal'tov [Comparative investigations of certain magnetic properties of directly and inversely magnetized effusive basalts]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 864-870, 1961.

From paleomagnetic investigations of the Pliocene effusive basalts of the Far Eastern Region of the U. S. S. R., a statistical analysis was made of correlations between systematic physical and chemical parameters of normally (N) and reversely (R) magnetized rocks. Certain magnetic properties of N and R samples are substantially and systematically different. From a comparison of field and laboratory studies of magnetic viscosity it was determined that viscous magnetization cannot be the only cause of I_n and Q differences of differently polarized samples. The observed reversed polarity of I_n of the samples can be explained both by the inversions of the earth's magnetic field as well as by one of the physical-chemical processes of self-reversal of thermoremanent magnetization. — A. J. S.

- 187-450. Smit, J., and Wijn, H. P. J. Ferrites: New York, John Wiley and Sons. 369 p., 1959.

The term "ferrites" is used to refer to all magnetic oxides containing iron as a major metallic component. In this text, the physical properties of ferrimagnetic oxides in relation to their technical applications are discussed on an intermediate level. Part A, theory, includes the following chapters: on the properties and the origin of magnetic fields in matter, theory of ferromagnetism, ferrimagnetism, magnetic anisotropies, magnetization processes, and dynamics of magnetization processes. Part B discusses methods of measuring ferromagnetic properties, and part C the intrinsic properties of ferrites with spinel structure, with hexagonal structure, and with garnet structure. Part D deals with the polycrystalline ferrites: their structure, electrical properties, static initial permeability, frequency-dependence of the initial permeability, static hysteresis loops, and dynamic properties at high field strengths. — V. S. N.

- 187-451. Kern, John W. Effects of moderate stress on directions of thermoremanent magnetization: *Jour. Geophys. Research*, v. 66, no. 11, p. 3801-3805, 1961.

Experiments designed to test the effects of directed stress on the thermoremanent magnetization (TRM) of igneous and metamorphic rocks are described. Basalt and andesite specimens exhibited no anomalous directions of TRM when cooled from 600°C under uniaxial stresses of up to 350 bars. Metamorphic rocks with preferred crystallographic orientations were found to exhibit anomalous directions of induced TRM after such treatment. These anomalous TRM directions were apparently related to the lineation of the specimens rather than applied stress. Residual magnetizations of the metamorphic specimens were found to approach the direction of the magnetizing field upon progressive alternating-field demagnetization. — Author's abstract

- 187-452. Kern, John W. Stress stability of remanent magnetization: *Jour. Geophys. Research*, v. 66, no. 11, p. 3817-3820, 1961.

A criterion is developed for determining the stress required to affect a given component of remanent magnetization. This criterion is associated with the process of alternating field (a-f) demagnetization currently used to eliminate unstable components of magnetization for paleomagnetic studies. It is concluded that any effects of magnetoelastic coupling, or magnetostriction, can be removed or minimized by a-f demagnetization, and that the components of magnetization that are most resistant to a-f demagnetization are most reliable for paleomagnetic measurements, especially if stress effects are thought to be present. — D. B. V.

- 187-453. Stott, P. M., and Stacey, F. D. Stress effects on thermoremanent magnetization: *Nature*, v. 191, no. 4788, p. 585-586, 1961.
Hall, J. M. Stress effects on thermoremanent magnetization: *Nature*, v. 191, no. 4788, p. 586, 1961.

Stott and Stacey point out that although Hall and Neale (see *Geophys. Abs.* 185-437) have reported more accurate measurements of the direction of remanent magnetization, they used specimens with appreciable intrinsic anisotropies (as much as 13 percent); therefore, their results are not inconsistent with those of Stott and Stacey (see *Geophys. Abs.* 176-268) concerning the effect of stress on remanent magnetization.

Hall replies that anisotropy appears to be of negligible importance in the production of thermoremanent stress effects, and that the anisotropies of the specimens used in the investigation were one percent or less in all but those having pyrrhotite as a magnetic component. — D. B. V.

- 187-454. Petrova, G. N. On magnetic stability of rocks: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 70-76, 1959.

This is an English version of the paper published previously in Akad. Nauk SSSR Izv. Ser. Geofiz., no. 1, p. 52-61, 1957 (see Geophys. Abs. 169-229). — V. S. N.

- 187-455. Carmichael, C[harles] M. The magnetic properties of ilmenite-hematite crystals: Royal Soc. [London] Proc., ser. A, v. 263, no. 1315, p. 508-530, 1961.

The magnetic properties of ilmenite-hematite solid solutions have been investigated, using the unusually large and pure hemo-ilmenite crystals from the Allard Lake region of Quebec. The magnetic component of these crystals is an ilmen-hematite phase (about 19 mole percent of ilmenite in hematite) present as exsolution lamellae roughly 5μ long, 1μ wide, and 0.2μ thick. The crystals have a very strong anisotropy causing magnetization in the basal plane and a weak anisotropy which produces an easy direction of magnetization within the basal plane.

An improved ilmenite-hematite solvus curve has been produced by X-ray and Curie-point analysis of heat-treated crystals. Spontaneous reversal of magnetic polarity takes place with change in temperature in ilmen-hematite having between 15 and 25 percent of ilmenite in hematite. This new reversing range of composition is quite different from that found by Uyeda (see Geophys. Abs. 175-291). The reversal is due to a new antiparallel moment which grows as temperature falls. This may be explained by an ordering of Fe^{2+} ions on alternate cation layers by an electron transfer mechanism between trivalent and divalent Fe atoms. — D. B. V.

- 187-456. Everitt, C. W. F. Thermoremanent magnetization: I. Experiments on single domain grains: Philos. Mag., v. 6, no. 66, p. 713-726, 1961.

Certain predictions by Neel concerning the properties of thermoremanent magnetization in fine-grained materials were tested by examining the effects of alternating-field demagnetization on a specimen that had been given partial and total thermoremanence. As predicted, a positive correlation was found between the blocking temperature and coercive force of individual magnetic grains. In confirmation of another of Neel's predictions, the ratio j_T/j_s of thermoremanence to spontaneous magnetization in grains with a particular blocking temperature T_B was found to be proportional to the hyperbolic tangent of the magnetizing field; but j_T/j_s was found to be independent of the coercive force of the grains, in apparent disagreement with a third prediction. In addition, the blocking temperatures were found to be almost independent of the magnetizing field up to 50 oersteds. — D. B. V.

- 187-457. Girdler, R. W. Some preliminary measurements of anisotropy of magnetic susceptibility of rocks: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 197-206, 1961.

Measurements have been made on four sets of rocks, two of which showed anisotropy of magnetic susceptibility and two were isotropic. The maximum and intermediate principal susceptibilities lie in the cleavage plane for some Welsh slates and in the horizontal plane for some igneous rocks of the Skaergaard layered intrusion. In both cases the directions of natural remanent magnetization have been affected. The two sets of isotropic rocks are from

the northern Pyrenees and Deccan of India, respectively. Both may have been affected by stress environments, the nature of which did not cause measurable anisotropy. It is unlikely that the directions of natural remanent magnetization have been affected for these rocks. — Author's summary

- 187-458. Rees, A. I. The effect of water currents on the magnetic remanence and anisotropy of susceptibility of some sediments: Royal Astron. Soc. Geophys. Jour., v. 5, no. 3, p. 235-251, 1961.

Study of the magnetic properties of fine silts deposited in the laboratory shows that the deviations of the directions of remanence and of maximum susceptibility caused by flow of water during deposition can be accounted for by an extension of the theory in which the sediment is considered as an assemblage of quasi-spherical particles which roll on deposition into hollows in the bed. The magnitude of the angle through which the particles are rotated is determined by an equilibrium between the shearing couple and the magnetic restoring couple.

A method is proposed for correcting for the effects of currents in natural sediments from measurements of their remanence and anisotropy of susceptibility, and a field test of its validity is suggested. — D. B. V.

- 187-459. Sasajima, Sadao. γ -Titanohematites in nature and the role they play in rock-magnetism: Jour. Geomagnetism and Geoelectricity (Kyoto), v. 12, no. 4, p. 190-215, 1961.

The laboratory techniques and results are reported of an investigation of the chemical, crystallographic, and magnetic properties of naturally occurring γ -hematites with titanium (γ -titanohematite or γ -tihatite). The occurrence of γ -tihatite is limited to pressure free and oxygen rich parts of the earth's crust; it is never found in deep-seated or metamorphic rocks unless they have suffered secondary alteration, but it does occur in igneous rocks such as propylite and altered green tuff and in some sediments. γ -tihatite is produced by low temperature hydrothermal oxidation of titanomagnetite, by the low temperature and very slow oxidation of titanomagnetite accompanying weathering, and by dehydration of lepidocrocite. The natural remanent magnetism is acquired at temperatures lower than the Curie point of the mineral and therefore may be attributed to chemical remanent magnetization or isothermal remanent magnetization. The intensity and stability of remanent magnetism of rocks containing γ -tihatite minerals are found to vary widely and are generally unstable as compared to that of titanomagnetite. — V. S. N.

- 187-460. Faynberg, F. S., and Semenov, A. S. Izmeneniye mineral'nogo sostava i magnitnoy vospriimchivosti zhelezosoderzhashchikh rud v zavisimosti ot temperatury [Change in mineral composition and magnetic susceptibility of iron-bearing ores depending on temperature]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 99-106, 1960.

An experimental study of high temperature effects on the magnetic susceptibility of weakly magnetized ore and other rocks due to variation in their mineralogical composition is reported. The samples were 4-5 cm cubes heated either in air or in a reducing medium to a temperature of 800°C. The results of the experiments are tabulated. — A. J. S.

- 187-461. Scott, G. G., and Meyer, André, J. P. Gyromagnetic ratio of pyrrhotite: Phys. Rev., v. 123, no. 4, p. 1269, 1961.

The gyromagnetic ratio of pyrrhotite, determined by measurements of the Einstein-deHaas effect, was found to be 1.9 ± 15 percent. — D. B. V.

- 187-462. Kalashnikov, A. G. Some results of investigation of magnetic properties of rocks and geological bodies: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 77-84, 1959.

This is virtually the same paper as that published in Akad. Nauk SSSR, Komitet po geodezii i geofizike, Tezisy dokladov na XI general'noy assamblee Mezhdunarodnogo Geodezicheskogo i Geofizicheskogo Soyuza [Theses of papers presented at the 11th general assembly of the International Union of Geodesy and Geophysics], p. 5-7, 1957 (see Geophys. Abs. 175-288). — V. S. N.

- 187-463. Laroche, A. Design of a Curie point meter: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Bull., no. 69, 18 p., 1961.

A torsion balance type instrument designed to determine the Curie point of ferromagnetic minerals in rock specimens is described in detail and illustrated. The instrument consists essentially of a torsion balance, a heating unit and thermocouple, an electromagnet, and a recording system. The Curie point of a substance is the temperature at which the substance loses its ferromagnetic properties (spontaneous magnetization) upon being heated. As this property depends entirely upon the chemical composition of the substance, it is useful in identifying the ferromagnetic members of a solid solution series present in a rock. Another application is the detection of the simultaneous presence in rocks of minerals of different Curie points. Such a coexistence has been proposed to account for in place reverse magnetic polarization of certain rocks. An investigation of this type in a suite of igneous rocks is described briefly. — V. S. N.

- 187-464. Bol'shakov, A. S. Ob ispol'zovanii astaticheskikh sistem mal'nykh razmerov [Application of astatic systems of small dimensions]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 7, p. 1025-1030, 1961.

The two astatic systems of Russian magnetometers used for paleomagnetic measurements are analyzed and compared: the Yanovskiy magnetometer with a distance $l=25-40$ cm between the magnets of the astatic system, and the Dolginov magnetometer with $l=7$ cm. The latter magnetometer is smaller and lighter weight. Its suspension filament is thinner; therefore, it has a higher sensitivity. The analysis was made to evaluate the experimental error due to the small value of l of Dolginov's magnetometer. It was found that the astatic system in which $l=1/2R_{\min}$ gives the same sensitivity for magnetization as that produced by the system in which l is infinitely long (R_{\min} is the minimum distance along the bar from the sample to the magnet). The errors due to the smaller l were found to be either negligibly small, or could be eliminated by accurate construction of the apparatus and by an appropriate method of measurement. — A. J. S.

- 187-465. Creer, K. M. Superparamagnetism in red sandstones: Royal Astron. Soc. Geophys. Jour., v. 5, no. 1, p. 16-28, 1961.

Susceptibility measurements were made down to liquid hydrogen temperatures on a Keuper red mudstone with unstable remanent magnetization and on an Old Red sandstone with stable remanent magnetization. The results show that most of the magnetic content of the former is apparently paramagnetic, and that in the latter an apparent paramagnetic component is present together

with a component having a susceptibility independent of temperature. In both cases the magnetization-applied field relationship is nonlinear, suggesting that both rocks contain ferromagnetic material in a superparamagnetic state, with a calculated particle size of the order of 20 Å; this material is thought to be hydrous α -Fe₂O₃ constituting the cement. The remanent magnetization of red rocks is thought to be due in part to the larger grains of red cement and in part to black hematite grains; these are more abundant in the stable rock.

Magnetization of the cement might occur soon after formation, or during a sintering process during deep burial, or in some cases during geologically recent tropical weathering. The calculated grain size of about 20 Å for the superparamagnetic particles differs appreciable from that of about 1,000 Å previously estimated for the viscously magnetized particles. Experiments are in progress to resolve this anomaly. — D. B. V.

Kopf, Manfred, and Wawrzik, Martin. Acoustic velocity and susceptibility measurements on rocks of the Triassic and Zechstein from the western Thuringian basin. See *Geophys. Abs.* 187-572.

187-466. Vasil'yev, A. V., and Semenov, A. S. Magnitnaya vospriimchivost' pochv [Magnetic susceptibility of soils]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 110-113, 1960.

An investigation of the magnetic susceptibility of soils in eastern Transbaikalia is reported. The K value for the soil was found to be several times larger than that of the bedrock (Jurassic deposits) and of alluvial conglomerates underlying the soil. Such an anomalous susceptibility is thought to be due to the presence of ferromagnetic minerals formed by biogenic activity. — A. J. S.

187-467. Stacey, F. D., Joplin, Germaine, and Lindsay, J. Magnetic anisotropy and fabric of some foliated rocks from S. E. Australia: *Geofisica Pura e Appl.*, v. 47, p. 30-40, 1960.

The magnetic anisotropy of several types of foliated rocks from southeast Australia, measured by the torque-meter method, shows that the alignment of long axes of magnetic grains in rocks normally follows the pattern of foliation evident in field observations. In a sharp fold in a *lit-par-lit* formation the magnetic anisotropy indicated an otherwise undetected lineation independent of the bedding, superimposed on the foliation determined by the layering. In two adamellites, each having two alignment patterns separated by an angle of 30°, the magnetic data are consistent with two foliations rather than with one foliation plus a lineation. Magnetic anisotropy data can be ambiguous for rocks in which two or more grain alignment processes have operated, but combined with other observations it can provide a valuable new tool in the study of rock fabrics. — D. B. V.

187-468. Khramov, A. N., Petrova, G. N., Komarov, A. G., and Kochegura, V. V. Metodika paleomagnitnykh issledovaniy [Methods of paleomagnetic investigations]: Leningrad, Gostoptekhizdat, 131 p., 1961.

Paleomagnetism is treated from the standpoint of the history of the earth's magnetic field; solution of problems of stratigraphy, geochronology, paleogeotectonics, and paleogeography; and certain problems of formation and evolution of rocks. After a discussion of the physical basis of paleomagnetism, the objectives and problems of paleomagnetic investigations are explained.

Subsequent chapters deal with the preparation for and conducting of paleomagnetic investigations at the desk, laboratory, and in the field. The field procedures include measurement of the natural magnetization I_n of samples, processing magnetometric data, stability evaluation of natural remanent magnetization of rocks, preparation of reports on paleomagnetic investigations and solution of geophysical and geological problems. In conclusion, the basic unsolved problems of the methods of paleomagnetic investigations are discussed. — A. J. S.

- 187-469. Irving, E., Stott, P. M., and Ward, M. A. Demagnetization of igneous rocks by alternating magnetic fields: *Philos. Mag.*, v. 6, no. 66, p. 225-241, 1961.

Secondary components of magnetization in basalts, the presence of which often limits their usefulness in paleomagnetic studies, can be removed by alternating magnetic fields. The procedures are described and tests based on the internal consistency of the results are devised to judge their reliability. These are applied successfully to a series of measurements on specimens from the Tertiary basalts of New South Wales, Australia. The Early Tertiary pole position calculated from these measurements is lat 63° S., long 137° E., in good agreement with that calculated earlier for the Older Volcanics of Victoria (see *Geophys. Abs.* 170-244). — D. B. V.

- 187-470. Griffiths, D[onald] H[arrison], King, R[oy] F[avell], and Wright, A. E. An assessment of the difficulties involved in using Quaternary varved sediments for palaeomagnetic studies of the secular variation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 11-14, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 515-518, 1958 (see *Geophys. Abs.* 176-264). — V. S. N.

- 187-471. DuBois, P. M. Palaeomagnetism and geological correlation [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 33-38, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 509-514, 1958 (see *Geophys. Abs.* 176-274). — V. S. N.

- 187-472. Blackett, P. M. S. Comparison of ancient climates with the ancient latitudes deduced from rock magnetic measurements: *Royal Soc. [London] Proc.*, v. 263, no. 1312, p. 1-30, 1961.

A systematic comparison has been made of the ancient magnetic latitudes of Europe, North America, India, Australia, and South Africa with the evidence of ancient climates as deduced from geological data, in particular from the distribution of salt, glaciations, and fossil corals. In spite of some discrepancies, the general agreement is close enough to lend support to the assumption that the ancient magnetic latitudes, calculated on the hypothesis of an axial dipole field, do represent also the ancient geographical latitudes. This support for the reliability of the magnetic data as a whole gives support for the hypothesis of continental drift and is opposed to the hypothesis that the earth's ancient field differed greatly from that of a dipole. — Author's abstract

- 187-473. Evison, F. F. Rock magnetism in western Europe as an indication of continental growth: *Royal Astron. Soc. Geophys. Jour.*, v. 4 (special volume), p. 320-335, 1961.

The paleomagnetic interpretation of rock magnetism has led to an increasingly elaborate set of geodynamic postulates, which now include polar wandering, continental drift, and the rotation of continents and parts of continents. An alternative approach is suggested by the hypothesis of widespread continual plastic flow of basement rocks. Remanence data for western Europe are analysed from this viewpoint, assuming that the position of the poles has always been virtually the same as at present. The inferred pattern of flow is away from the high standing interior and towards the Northeastern Atlantic Basin. The amount of flow increases with the age of the rock; an accelerated rate of flow is indicated during the Hercynian revolution and a relatively slow rate in more recent times. These results are in accord with the concept of continental growth by plastic flow under gravity. — Author's summary

- 187-474. Creer, K. M., Irving, E., Nairn, A. E. M., and Runcorn, S. K[leith]. Paleomagnetic results from different continents and their relation to the problem of continental drift [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 1-10, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 4, p. 492-501, 1958 (see *Geophys. Abs.* 176-273). — V. S. N.

- 187-475. Irving, E. Paleomagnetic directions and pole positions, part 3. Pole numbers 3/1 to 3/87: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 1, p. 70-79, 1961.

The results of 87 paleomagnetic determinations available since part 2 (see *Geophys. Abs.* 184-490) are compiled in a 20-column table. — D. B. V.

- 187-476. Bowen, Robert. Paleotemperature analyses of Belemnoides and Jurassic paleoclimatology: *Jour. Geology*, v. 69, no. 3, p. 309-320, 1961.

One hundred specimens of Jurassic Belemnoides of world-wide origin were analyzed and their paleotemperature record compiled from mass-spectrometric measurements; their δ -values in parts per mil are averages of whole specimens and are related to the standard PDB-1. Results obtained are compared with those of paleomagnetism and other fields of investigation. It is shown that in the Jurassic the earth had larger tropical and semitropical belts than at present. The positions of the poles remain uncertain but the North Pole probably occupied a position somewhere in east Asia; India lay in the temperature zone much farther from the equator than at present; Alaska and New Guinea were both cool-water areas; and the poles were much warmer than at present showing a temperature range around 20° as compared with about 60° today. — V. S. N.

- 187-477. Doell, Richard R., and Cox, Allan [V.]. Palaeomagnetism of Hawaiian lava flows: *Nature*, v. 192, no. 4803, p. 645-647, 1961.

Remanent magnetization has been measured on at least one specimen from each of 152 Hawaiian lava flows sampled so far. Results of these preliminary measurements are summarized as follows: (1) The historic flows have directions of magnetization closely grouped about the present geomagnetic field direction; (2) none of the flows shows reversed polarity; (3) the scatter in directions from flow to flow in a given sequence is much smaller than generally reported in comparable studies elsewhere; (4) the average directions of mag-

netization of most of the thick sequences appear to differ significantly both from the present geomagnetic field and from the theoretical dipole field, and average directions in different sequences differ from each other.

If the geomagnetic field reversal theory is true, all the flows sampled are younger than early Pleistocene. The results on the thick sequences suggest that low rates of secular variation have prevailed in Hawaii; the results from the historic flows support this interpretation, and direct measurements back to about 1900 also show less secular variation (less than 2 percent) than is typical elsewhere in the world. — D. B. V.

- 187-478. Larochelle, A. Application of palaeomagnetism to geological correlation: *Nature*, v. 192, no. 4797, p. 37-39, 1961.

Pole positions calculated from paleomagnetic measurements on rocks from Mount Megantic, 75 miles east of the Monteregian Hills in Quebec, are shown stereographically and compared with the positions inferred from rocks from the Monteregian Hills and dated rocks from elsewhere in North America. A Cretaceous age for both the Monteregian Hills and Mount Megantic is indicated. Recent K-Ar dating also confirms both the synchronicity and the Cretaceous age of the two rock units. — D. B. V.

- 187-479. Creer, K. M. Preliminary palaeomagnetic measurements from South America [with French abstract]: *Internat. Assoc. Geomagnetism and Aeronomy Bull.*, no. 16a, p. 15-32, 1959.

This paper was published previously in *Annales Géophysique*, v. 14, no. 3, p. 373-390, 1958 (see *Geophys. Abs.* 179-321). — V. S. N.

- 187-480. Wilson, R. L. Palaeomagnetism in Northern Ireland. Pt. 1—The thermal demagnetization of natural magnetic moments in rocks: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 1, p. 45-58, 1961.

A paleomagnetic investigation of some hematite- and maghemite-bearing baked laterites underlying Tertiary lava in Northern Ireland is described. A thermal demagnetization technique eliminated a secondary component of magnetization along the present earth's field, revealing that the lava and baked laterite agree in direction. This allowed a determination of the strength of the earth's field (reversed at the time of baking) and the temperature of baking.

This determination of a geologically ancient field strength is particularly significant, as many such determinations from rocks of different ages might allow estimates of ancient latitudes for the various continents, independent of estimates derived from directions of magnetization. — D. B. V.

- 187-481. DuBois, R. L. Remanent magnetization of Carboniferous limestone: *Royal Astron. Soc. Geophys. Jour.*, v. 5, no. 3, p. 230-234, 1961.

The remanent magnetization of Carboniferous limestone contiguous to iron ore in England was measured. The average declination of S. 41° W. and inclination of -29° correspond to a pole position of lat 40° N., long 122° E. Intensities of remanent magnetization range between 0.4×10^{-6} and 27.5×10^{-6} emu per cm³. — D. B. V.

- 187-482. Bidgood, D. E. T. Differential secondary magnetization in some British Cambrian rocks: *Nature*, v. 192, no. 4797, p. 39-40, 1961.

Magnetic results were obtained for 11 out of 12 oriented specimens from 3 horizons in the Hartshill quartzites and Hyolithus limestones from 2 localities near Nuneaton, England. The direction of remanent magnetization of the quartzites was similar to that of Cambrian rocks from Wales, but the mean vector for the limestones was about 90° removed. After demagnetization both groups showed a reduction in the amount of scatter, and both showed a displacement toward the southwest that cannot be attributed to removal of a secondary component parallel to the present geomagnetic field. The change in intensities produced by a-c washing was markedly different (the limestones lost about 85 percent whereas the quartzites showed little change), suggesting that the two rock types have taken on very different components of secondary magnetization.

The observations may be explained as follows: The quartzites and limestones, both weakly magnetized parallel to the Cambrian geomagnetic field, were brought to or near the surface by uplift and erosion by Triassic time. While the thick Triassic red beds, now exposed to the northwest, were being deposited, the Cambrian rocks were penetrated by iron-bearing ground waters which, in depositing new iron minerals and oxidizing existing minerals to new forms, imposed a chemical remanent magnetization; as this process depended on permeability, it was more extensive in the limestones.

If the quartzites after washing give the true record, the Cambrian pole lay at lat 18° N., long 165° E.; this is in good agreement with those calculated for British and Norwegian Cambrian rocks. — D. B. V

- 187-483. Deutsch, E. R., Radakrishnamurty, C., and Sahasrabudhe, P. W. Palaeomagnetism of the Deccan Traps [with French abstract]: Internat. Assoc. Geomagnetism and Aeronomy Bull., no. 16a, p. 39-59, 1959.

This paper was published previously in *Annales Géophysique*, v. 15, no. 1, p. 1-21, 1959 (see *Geophys. Abs.* 177-303). — V. S. N.

- 187-484. Faynberg, F. S. Ob anomal'noy namagnichennosti trappov v nizhnem techenii r. Chunya [On the anomalous magnetization of traps on the lower course of the Chuna River]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 107-109, 1960.

The results of investigations of magnetic properties of 300 samples taken from 10 large trap outcrops in the Chuna River area of eastern Siberia are reported. It was found that in nine outcrops the remanent magnetization varies between -80° and -20° , and in one outcrop $i=+6^\circ$. It was also established that the angle of "inclination" of the I_r vector and the ratio of I_r/I_i have a correlation such that the traps of higher remanent magnetization have a large (about 80°) negative "inclination." — A. J. S.

- 187-485. Kochegura, V. V., and Sholpo, L. Ye. K voprosu o magnitnoy stabilnosti izverzhennykh porod [On the problem of magnetic stability of igneous rocks]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 149-156, 1960.

The magnetic properties were determined for rock samples taken on a 170 m profile in Eocene basaltic lava in the Far Eastern Region of the U. S. S. R. The directions of the vectors of natural remanent magnetization are distinctly different from the direction of the present magnetic field of the earth, having sometimes a reversed polarity. The experiments showed, however, that in

spite of the reversed polarity preserved for millions of years, the possibility of considerable changes both in direction and magnitude of magnetization of these rocks is not excluded. — A. J. S.

- 187-486. Sholpo, L. E. Paleomagnitnyye issledovaniya v zonakh perekhoda ot normal'no k obratno namagnichennym tolshcham [Paleomagnetic investigations in transition zones from normally to inversely magnetized formations]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 157-159, 1960.

The results of paleomagnetic investigations of samples taken from 14 outcrops of plateau basalts in the Primorskiy and Khabarovsk regions and in Kamchatka are discussed. The value of the Q -ratio of samples taken from normally magnetized layers of lava is on the average considerably greater than that taken from inversely magnetized layers. This observation is considered to be important for further investigations of the paleomagnetic problem. — A. J. S.

- 187-487. Kochegura, V. V., and Sholpo, L. Ye. Paleomagnitnyye issledovaniya dal'nevostochnykh bazal'tov [Paleomagnetic investigations of basalts from the Far East]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 160-164, 1960.

The results of paleomagnetic investigations of more than 500 samples taken from 26 outcrops in central Kamchatka, the Sovetskaya Gavan region, and the southern part of the Primorskiy region, U. S. S. R., are reported. According to their I_n vectors, the Neogene basalts are composed of alternate layers of normally and inversely magnetized lava. The coordinates of the magnetic poles calculated for each normally magnetized horizon were found to differ considerably from the coordinates determined for the inversely magnetized horizons. However, the mean position of the earth's magnetic pole during the period of the normal and reversed magnetization observed was found to coincide with the present position of the geographic pole of the earth. The positions of the magnetic pole during the Neogene suggest two components of magnetic moment of the earth: the M_a component along the geographic axis of the planet, and the M_e component in the plane perpendicular to M_a . The first determines the polarity of the earth's magnetic field and undergoes periodic inversion, while the M_e component (1/10 of the total magnetic moment) maintains an approximately constant direction. A certain correlation between secular variation of the earth's magnetic field and the process of extrusion of lava flows is suggested. — A. J. S.

- 187-488. Hibberd, F. H. Secondary magnetization and the palaeomagnetism of some Pliocene rocks of Japan: Jour. Geomagnetism and Geoelectricity [Kyoto], v. 12, no. 4, p. 222-226, 1961.

The effect of secondary magnetization on the apparent position and polarity of a paleomagnetic pole is examined and applied to measurements made by Momose [see Geophys. Abs. 178-298] on Pliocene rocks. It appears that in the Lower-Middle Pliocene the pole was near 70° N., 150° W., and that the polarity in the Lower Pliocene was normal and in the Middle Pliocene was reversed. A reversal of the earth's field appears to have occurred near the Lower-Middle Pliocene boundary. — Author's abstract

- 187-489. Green, Ronald. Palaeomagnetism of some Devonian rock formations in Australia: Tellus, v. 13, no. 1, p. 119-126, 1961.

The directions of remanent magnetization are found to be remarkably consistent throughout the Canberra volcanics and porphyries, the Murrumbidgee sandstones, and the Nethercote basalts in southern New South Wales, Australia; these formations are Late Silurian-Early Devonian, Middle Devonian, and Late Devonian in age. The low inclination indicates that throughout this period Australia lay $10-15^\circ$ away from the equator, the pole lying in the South Atlantic at lat 64.9° S., long 19.6° W. The rocks are evidently magnetically stable. The paleomagnetic data support the belief that southeast Australia experienced tropical conditions during the Devonian. — D. B. V.

- 187-490. Boesen, R., Irving, E., and Robertson, W. A. The palaeomagnetism of some igneous rock bodies in New South Wales: Royal Soc. New South Wales Jour. and Proc., v. 94, pt. 6, p. 227-232, 1961.

Measurements of direction and intensity of magnetization of rock specimens from four igneous bodies—Prospect intrusion, Gibraltar syenite, Gingenbullen dolerite, and some Tertiary basalts—in eastern New South Wales are given in tables, and the interpretation of the results discussed. The directions of natural remanent magnetization in the Prospect dolerite, the Gibraltar syenite, and the Gingenbullen dolerite (after treatment in 150 oersteds) are stable and may be identified with the direction of the geomagnetic field at the time these intrusions cooled. Assuming that the geomagnetic field at those times was that of a geocentric dipole, the pole positions (south) are calculated and found to be in the region of Tasmania near the pole obtained previously for the Tasmanian dolerites (see Geophys. Abs. 166-280) but lower in latitude than that obtained for the Older Volcanics of Victoria (see Geophys. Abs. 173-290). This suggests that these intrusions are older than the latter and of an age comparable to the former, that is, they are Mesozoic.

The study of the Tertiary basalts (Berrima, Moss Vale, and Robertson area) is part of a general paleomagnetic study of Tertiary basalts of New South Wales. The stability results will be reported in another paper. — V. S. N.

MAGNETIC SURVEYS

- 187-491. Alldredge, Leroy R., and Van Voorhis, Gerald D. Depth to sources of magnetic anomalies: Jour. Geophys. Research, v. 66, no. 11, p. 3793-3800, 1961.

The characteristics of several long magnetic total field intensity profiles, all nearly straight and more than 2,000 miles long, have been determined. After obtaining a real nondipole field by subtracting the centered dipole field total intensity, a smooth curve was drawn through this nondipole field using a stiff spline curve. The distance between crossover points of the smooth field and the nondipole field was determined and the results plotted on a histogram.

The results confirm the fact that most anomalies have a very short wavelength; 93 percent had crossover distances of less than 60 nautical miles. The form of the smooth curves indicates a nearly sinusoidal departure from a dipole field having crossover points between 2,100 and 5,200 nautical miles. The most natural explanation is that the short-wave length anomalies are due to crustal effects and the long-wave length anomalies to causes within the core. The large gap between groupings supports the hypothesis that the mantle is a forbidden region for magnetic sources. Calculations based on simple models illustrate this conclusion. — D. B. V.

- 187-492. Wesley, James Paul. Oscillating vertical magnetic dipole above a conducting half-space: California Univ. Lawrence Radiation Lab., UCRL-6467, 17 p., 1961.

The electromagnetic field produced by a vertical oscillating magnetic dipole above a plane conducting earth is obtained in integral form. An exact solution in closed form is obtained for the dipole and the point of observation located on the surface of the earth. For points of observation less than a wavelength in the conducting earth away from the source, $k_1\rho < [k_2\rho] < 1$, the magnetic field varies as ρ^{-3} and the electric field as ρ^{-2} . For distances from the source greater than a wavelength in the conducting earth but less than a wavelength in air, $k_1\rho < 1 < [k_2\rho]$, the magnetic field varies as ρ^{-m} where $2 < m < 3$, and the electric field as ρ^{-n} where $2 < n < 3$. For distances greater than a wavelength in air, both the electric and magnetic field components vary as ρ^{-2} . — V. S. N.

- 187-493. Smith, R. A. Some theorems concerning local magnetic anomalies: *Geophys. Prosp.*, v. 9, no. 3, p. 399-410, 1961.

Formulas are derived and discussed that can be applied, with negligible computation, to either total field or vertical magnetometer observations to yield limits to the depth and intensity of magnetization of the disturbing bodies. (See also *Geophys. Abs.* 177-305.) — D. B. V.

- 187-494. Watkins, N. D. The relative contributions of remanent and induced magnetization to the observed magnetic field in northeastern Alberta: *Geophys. Prosp.*, v. 9, no. 3, p. 421-426, 1961.

The ratios of induced to remanent magnetic intensities have been determined for samples of Precambrian rock from the Canadian shield in northeastern Alberta. The remanent magnetization is found to be relatively insignificant and can be assumed to be zero in interpretation of magnetic anomalies.

Some other implications of the magnetic measurements are discussed briefly. These include the use of reverse remanent magnetization as an indication of overturning; the decrease of intensity of remanent magnetization with age, and the value of an aeromagnetic map in resolving some geologic mapping problems in a highly diversified metamorphosed area. — D. B. V.

- 187-495. Polonskiy, A. M. Ovychnisleniy magnitnykh momentov trekhmernykh tel [On calculation of magnetic moments of three-dimensional bodies]: *Akad. Nauk SSSR Izv. Ser. Geofiz.*, no. 6, p. 871-875, 1961.

The magnetic moments (M) of spherical or prolate ellipsoidal bodies are discussed, and an approximate method of calculation is proposed. Instead of using the horizontal component H of the field in the calculation, a formula using the vertical field component Z is proposed: $M = -\frac{1}{2\pi} \int \int X(\xi, \eta) \xi d\xi d\eta$, where X is a projection of the horizontal component, H, on the x-axis. This formula is applicable for any nonvertical magnetization of these bodies, and for the sphere the maximum error is 6.4 percent (see also Mikov, *Geophys. Abs.* 169-240). — A. J. S.

- 187-496. Ponomarev, V. N. Vertikal'nyye gradiyenty vertikal'noy sostavlyayushchey magnitnogo polya i tekhnika ikh izmereniy [Vertical

gradients of the vertical component of the magnetic field and the technique of their measurements]: *Prikladnaya Geofizika*, no. 25, p. 157-176, 1960.

This is a mathematical analysis of variation characteristics of the magnetic field gradient Z'_z when measured simultaneously with its anomalous vertical component Z by a magnetometer of the MP-1 type. The vertical gradients Z'_z for spherical bodies and for an infinitely extended horizontal layer are calculated, and anomalies of Z and Z'_z produced by several bodies are discussed. The methods of depth determination for disturbing bodies of simple geometry are given. Errors in determination of geophysical parameters by the methods discussed are evaluated, and suggestions are made for improvement in the technique of Z'_z determination. — A. J. S.

Troshkov, G. A., and Shalayev, S. V. Application of Fourier transformation to solutions of the inverse problem of gravity and magnetic prospecting. See *Geophys. Abs.* 187-289.

Avdulov, M. V. On interpretation of gravity and magnetic observations by the method of theoretical fields. See *Geophys. Abs.* 187-296.

187-497. Jensen, Homer. The airborne magnetometer: *Sci. American*, v. 204, no. 6, p. 151-156, 158-162, 1961.

The revolution in mineral exploration brought about by the use of the airborne magnetometer and related techniques is discussed. The nature of the magnetic field of the earth and its regional irregularities and small scale disturbances that may be detected by the airborne instruments are reviewed. Characteristic anomaly curves and results in terms of contour maps are shown. The nature of the magnetometer and a typical installation in a plane are described and illustrated. — V. S. N.

187-498. Jenny, W. P. High aeromagnetic accuracy provides detailed coverage: *World Oil*, v. 153, no. 4, p. 90-92, 1961.

With present instruments and techniques, continuous aerial micromagnetic profiles can be surveyed for 50-100 miles with an accuracy that can be reproduced to $\pm \frac{1}{2}$ gamma. A dual level arrangement is used in which one instrument is attached to the tail of the aircraft and the other is flown on a cable 200 feet below. This arrangement allows selection of the more effective level of operation. Records of profiles flown over a salt dome in the Gulf of Mexico illustrate the reproducibility of measurements by the micromagnetic method. — J. W. C.

187-499. Rikitake, Tsuneji, and Tanaoka, Iwao. A differential proton magnetometer: *Tokyo Univ. Earthquake Research Inst. Bull.*, v. 38, pt. 2, p. 317-328, 1960.

A magnetometer that records the difference in total geomagnetic intensity between two points is described. By mixing the signals caused by free precession of protons from the two detecting coils, the best signal is recorded on a pen-writing oscillograph. Present accuracy of the differential magnetometer is about 0.27 per 10 m; this can be increased by increasing the distance between the coils. The apparatus was designed to detect very local anomalies accompanying activity of Mihara Volcano. — D. B. V.

- 187-500. Kudryavtsev, Yu. I. Chastotnyy metod izmereniya v karotazhe magnitnoy vospriimchivosti [The frequency method of measuring in logging of magnetic susceptibility]: Leningrad. Univ. Uchenyye Zapiski, Voprosy Geofiziki, no. 286, p. 87-98, 1960.

The pickup system for the magnetic susceptibility method of logging is discussed, and two variants of this instrument are proposed. The pickup consists of a cylindrical induction coil of length l having a core of diameter d and an effective permeability μ_d . It is operated on a stabilized current of frequency f and voltage V in its coil when in the air. The voltage V changes for a value $\Delta V = \text{function}(\mu \delta D)$ when placed in a borehole; μ is the rock permeability (the susceptibility K may be used instead), δ is the rock's electric conductivity, and D is the borehole diameter. The circuit diagrams for the K -logging apparatus based on the frequency-impulse principle and the frequency-semiconductor are given. The apparatus was tested in a borehole in the area of an iron deposit and showed a satisfactory performance. — A. J. S.

- 187-501. Bromery, Randolph W., Zandle, Gerald L., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-239-GP-245, GP-254-GP-259, GP-266-GP-268, GP-270-GP-278, and GP-280-GP-282, 1961.

Aeromagnetic maps have been published at a scale of 1:24,000 (1 inch = about 2/5 mi) for the following: 239, Womelsdorf quadrangle, Berks, Lebanon, and Lancaster Counties; 240, Sinking Spring quadrangle, Berks and Lancaster Counties; 241, Ephrata quadrangle, Lancaster County; 242, Terre Hill quadrangle, Lancaster and Berks Counties; 243, Leola quadrangle, Lancaster County; 244, New Holland quadrangle, Lancaster County; 245, Gap quadrangle, Lancaster County; 254, Lebanon quadrangle, Lebanon County; 255, Richland quadrangle, Lebanon and Lancaster Counties; 256, Manheim quadrangle, Lancaster and Lebanon Counties; 257, Lititz quadrangle, Lancaster and Lebanon Counties; 258, Columbia East quadrangle, Lancaster County; 259, Lancaster quadrangle, Lancaster County; 266, part of the Alburts quadrangle, Lehigh, Berks, and Northampton Counties; 267, part of the Hummelstown quadrangle, Dauphin County; 268, part of the Palmyra quadrangle, Dauphin and Lebanon Counties; 270, York quadrangle, York County; 271, Red Lion quadrangle, York County; 272, Glen Rock and part of the New Freedom quadrangles, York County; 273, part of the Bernville quadrangle, Berks County; 274, part of the Mechanicsburg quadrangle, Cumberland and York Counties; 275, New Cumberland quadrangle, Cumberland, Dauphin, and York Counties; 276, part of the Mount Holly Springs quadrangle, Adams, Cumberland, and York Counties; 277, part of the Dillsburg quadrangle, Adams, York, and Cumberland Counties; 278, part of the Arendtsville quadrangle, Adams and Cumberland Counties; 280, Hampton quadrangle, Adams and York Counties; 281, Abbottstown quadrangle, Adams and York Counties; and 282, West York quadrangle, York County. — W. L. G.

- 187-502. Bromery, Randolph W., Natoff, Nora C., and others. Aeromagnetic maps of Pennsylvania: U. S. Geol. Survey Geophys. Inv. Map GP-269, and GP-284-GP-287, 1961.

Aeromagnetic maps have been published at a scale of 1:24,000 (1 inch=about 2/5 mile) for the following: 269, Middletown quadrangle, Dauphin, Lancaster, Lebanon, and York Counties; 284, Gettysburg quadrangle and part of the Taneytown quadrangle, Adams County; 285, McSherrystown quadrangle and part of the Littlestown quadrangle, Adams County; 286, Hanover quadrangle

and part of the Manchester quadrangle, Adams and York Counties; and 287, Seven Valleys quadrangle and part of the Lineboro quadrangle, York County, — W. L. G.

- 187-503. Bromery, Randolph W., White, Bernard L., and others. Aeromagnetic map of part of the Fairfield quadrangle and part of the Emmitsburg quadrangle, Adams County, Pennsylvania, and Frederick County, Maryland: U. S. Geol. Survey Geophys. Inv. Map GP-283, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 500 feet above ground level for part of the Fairfield quadrangle, Adams County, Pennsylvania, and part of the Emmitsburg quadrangle, Frederick County, Maryland. — W. L. G.

- 187-504. Eargle, D. H[oye], Trumbull, J. V. A., and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic maps of Texas: U. S. Geol. Survey Geophys. Inv. Map GP-246, GP-248, and GP-251, 1961.

Preliminary aeroradioactivity and geologic maps that show by contour lines the total intensity at about 500 feet above ground level have been published for the following: 246, Floresville SE quadrangle, Karnes and Wilson Counties; 248, Stockdale SE quadrangle, Karnes, De Witt, and Wilson Counties; and 251, Karnes City NW quadrangle, Karnes County. — W. L. G.

- 187-506. Trumbull, J. V. A., Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Stockdale SW quadrangle, Karnes and Wilson Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-247, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch=about 1/2 mile) for the Stockdale SW quadrangle, Karnes and Wilson Counties. — W. L. G.

- 187-506. Brown, R. D. Jr., Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic maps of Texas: U. S. Geol. Survey Geophys. Inv. Map GP-249 and GP-250, 1961.

The following preliminary aeroradioactivity and geologic maps have been published at a scale of 1:31,680 (1 inch=about 1/2 mile): 249, Falls City NW quadrangle, Atascosa, Karnes, and Wilson Counties; and 250, Falls City NE quadrangle, Karnes and Wilson Counties. — W. L. G.

- 187-507. Eargle, D. H[oye], Brown, R. D., Jr., and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Falls City SW quadrangle, Atascosa, Karnes, and Live Oak Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-252, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch=about 1/2 mile) for the Falls City SW quadrangle, Atascosa, Karnes, and Live Oak Counties. — W. L. G.

- 187-508. Eargle, D. H[oye], and Moxham, R[obert] M. Preliminary aeroradioactivity and geologic map of the Falls City SE quadrangle, Atascosa, Karnes, and Live Oak Counties, Texas: U. S. Geol. Survey Geophys. Inv. Map GP-253, 1961.

This preliminary aeroradioactivity and geologic map has been published at a scale of 1:31,680 (1 inch=about 1/2 mile) for Falls City SE quadrangle, Atascosa, Karnes, and Live Oak Counties. — W. L. G.

- 187-509. Pemberton, Roger H. Geophysical survey coverage in Canada: Canadian Mining Jour., v. 82, no. 4, p. 84-88, 1961.

The currently available airborne magnetometer survey coverage of Canada sponsored by the Dominion and the provinces and that available from various airborne survey contractors in Canada are shown on maps. "Operation Research" is discussed to show how and why those engaged in mining exploration can use this approach to solve their primary problem of finding more orebodies. Many complex problems are involved in the interpretation of magnetic survey results, but time spent in analyzing the problems beforehand and calculating not only the probabilities but also the best profit return per dollar spent increases the chances of success. An airborne magnetic survey to locate sulfide deposits in the Mattagami district is discussed as an example. — V. S. N.

- 187-510. Canada Geological Survey. Aeromagnetic maps of Gulf of St. Lawrence: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 1012G, 1015G-1024G, 1960.

The following aeromagnetic maps have been published at a scale of 1:63,360 (1 inch=1 mile) for the Gulf of St. Lawrence area: 1012G, and 1015G-1024G. — W. L. G.

Fleming, H. W., and Brooks, R. R. Geophysical case history of the Clearwater deposit, Northumberland County, New Brunswick, Canada. See Geophys. Abs. 187-192.

- 187-511. Canada Geological Survey. Aeromagnetic maps of Ontario: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 960G-1009G, 1960; and 1100G-1139G, 1961.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 500 feet above ground level have been published for the following: 960G, Mojikit Lake, 961G, D'Orsonnens Lake, 962G, Sim Lake, Thunder Bay District; 963G, Kawitos Lake, 964G, Opikieigen Lake, Kenora and Thunder Bay Districts; 965G, Machawaian Lake, 966G, Kabanian Lake, 967G, Nankika Lake, 968G, Sagiminnis Lake, 969G, Wapikopa Lake, Kenora District; 970G, Makoki Lake, 971G, Mahamo Lake, Thunder Bay District; 972G, Kellow Lake, 973G, Triangular Lake, Kenora and Thunder Bay District; 974G, Fort Hope, 975G, Stark Lake, 976G, Lansdowne House, 977G, Wapitotem Lake, 978G, Mameigwess Lake, 979G, Kanuchuan Lake, Kenora District; 980G, Kapikotongwa Lake, 981G, Ogoki Lake, Thunder Bay District; 982G, Harvey Lake, 983G, Makokibatana Lake, Kenora and Thunder Bay Districts; 984G, McIntyre Lake, 985G, Norton Lake, 986G, Windsor Lake, 987G, Owen Lake, 988G, Pulham Lake, 989G, Winisk Lake, Kenora District; 990G, Percy Lake, 991G, Patience Lake, 992G, Dusey Lake, 993G, Kagiama Falls, 994G, Maxey Lake, Thunder Bay and Cochrane Districts; 995G, Wabassi Falls, 996G, Shibley Lake, 997G, Kitchie Lake, 998G, Goods Lake, 999G, Prime Lake, Kenora District; 1000G, Louella Falls, 1001G, La Rose Lake, 1002G, Eby Falls, 1003G, Big Canoe Lake, Cochrane District; 1004G, Nottik Island, 1005G, Sebert Lake, Cochrane and Kenora Districts; 1006G, Pym Island, 1007G, Fishtrap Lake, 1008G, Symons Lake, and 1009G, Greig Lake, Kenora District.

The following aeromagnetic maps show by contour lines the total magnetic intensity at about 1,000 feet above ground level: 1100G, Arrow Lake, 1101G, Perching Gull Lake, 1102G, Shebandowan Lake, 1103G, Savanne, 1104G, Upsala, 1105G, Pakashkan Lake, 1106G, Weaver Lake, 1107G, Harmon Lake, 1108G, Seseganaga Lake, 1109G, Barrington Lake, Thunder Bay District; 1110G, Gunflint Lake, 1111G, Titmarsh Lake, 1112G, Huronian, 1113G, Bedivere Lake, Rainy River and Thunder Bay Districts; 1114G, Firesteel River, Kenora, Rainy River and Thunder Bay Districts; 1115G, Petry, 1116G, Cottle Lake, 1117G, Bell Lake, 1118G, Sturgeon Lake, 1119G, Kashawegama Lake, Kenora and Thunder Bay Districts; 1120G, Louisa Lake, 1121G, Kawnipi Lake, 1122G, Pickerel Lake, 1123G, Sapawe, Rainy River District; 1124G, Gulliver Lake, Kenora and Rainy River Districts; 1125G, Bonheur, 1126G, Unaka, 1127G, Watcomb, 1128G, Ycliff, 1129G, Schist Lake, Kenora District; 1130G, Crooked Lake, 1131G, Poohbah Lake, 1132G, Kasakokwog Lake, 1133G, Steep Rock Lake, Rainy River District; 1134G, White Otter Lake, Kenora and Rainy River Districts; 1135G, Ignace, 1136G, Nameigwess Lake, 1137G, Yonde, 1138G, Sioux Lookout, and 1139G, Expanse Lake, Kenora District. — W. L. G.

- 187-512. Canada Geological Survey. Aeromagnetic maps of Manitoba: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Papers 1029G-1044G, 1047G-1050G, 1055G-1058G, 1064G, 1065G, 1072G, 1073G, 1078G-1083G, and 1086G-1091G, 1961.

Aeromagnetic maps that show by contour lines the total magnetic intensity at about 1,000 feet above ground level have been published for the following quadrangles: 1029G, Egenolf Lake; 1030G, Whitmore Lake; 1031G, Colbeck Lake; 1032G, Erickson Lake; 1033G, Snyder Lake; 1034G, Thanout Lake; 1035G, Hugill Creek; 1036G, Finner Lake; 1037G, Turner Lake; 1038G, Sucker Lake; 1039G, Kasmere Lake; 1040G, Wolk Lake; 1041G, Veal Lake; 1042G, Tice Lake; 1043G, Putahow Lake; 1044G, Bagg Lake; 1047G, Goldsand Lake North; 1048G, Carswell Lake; 1049G, Carriere Lake; 1050G, Carlson Lake; 1055G, Hjalmarson Lake; 1056G, Sawbill; 1057G, Brochet; 1058G, Abram Lake; 1064G, Engen Lake; 1065G, Whiskey Jack Lake; 1072G, Lac Brochet; 1073G, Misty Lake; 1078G, Munroe Lake; 1079G, Canfield Lake; 1080G, Doig Lake; 1081G, Booth Lake; 1082G, Calder Lake; 1083G, Sandhill Lake; 1086G, Askey Lake; 1087G, Corbett Lake; 1088G, Drake Lake; 1089G, Todd Island; 1090G, Lowry Lake; and 1091G, Blevins Lake. — W. L. G.

- 187-513. Canada Geological Survey. Aeromagnetic map of Saskatchewan and Manitoba: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Paper 1028G, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 500 feet above ground level for the Coronation Mine area. — W. L. G.

- 187-514. Canada Geological Survey. Aeromagnetic map of Northwest Territories: Canada Geol. Survey, Dept. of Mines and Tech. Surveys, Geophys. Paper 1027G, 1961.

This aeromagnetic map shows by contour lines the total intensity at about 1,000 feet above ground level for the magnetic anomaly east of Quinn Lake, District of MacKenzie. — W. L. G.

Stewart, Harris B., Jr., Raff, Arthur D., and Jones, E. L. Explorer Bank—a new discovery in the Caribbean. See Geophys. Abs. 187-606.

- 187-515. Vacquier, Victor, Duff, Arthur D., and Warren, Robert E. Horizontal displacements in the floor of the northeastern Pacific Ocean: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1251-1258, 1961.

A total magnetic intensity survey in the northeastern Pacific Ocean revealed a north-south pattern of magnetic anomalies, which is cut through by the Murray, the Pioneer, and the Mendocino faults. The amount of slip along these faults is measured by fitting the magnetic anomaly pattern across the faults. The combined left-lateral displacement across the Mendocino and the Pioneer faults is 1,420 km. — Authors' abstract

- 187-516. Mason, Ronald G., and Raff, Arthur D. Magnetic survey off the west coast of North America, 32° N. latitude to 42° N. latitude: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1259-1260, 1961.

A ship-towed magnetometer survey of an area 250-300 miles wide off the foot of the continental slope along the coast of California has revealed a narrow pattern of anomalies of about 400 gammas magnitude trending north-south for more than 500 miles. The pattern is interrupted at the known faults and elsewhere; offset of the pattern at the Murray fault suggests a right-lateral displacement of about 84 nautical miles. The anomalies are such as might be expected of slablike structures underlying the ocean floor; geological possibilities include basic lava flows, topography of the main crustal layer, and intrusion of ultrabasic material from the mantle. — Authors' abstract

- 187-517. Raff, Arthur D., and Mason, Ronald G. Magnetic survey off the west coast of North America, 40° N. latitude to 52° N. latitude: *Geol. Soc. America Bull.*, v. 72, no. 8, p. 1267-1270, 1961.

An extensive high-resolution magnetic survey of total field at sea level reveals unusual north-south lineations and much crustal faulting. Computations indicate that the linear pattern is due to strongly magnetized mafic rocks beneath the sediments. — Authors' abstract

- Raff, Arthur D. The magnetism of the ocean floor. See *Geophys. Abs.* 187-612.

- 187-518. Engineering and Mining Journal. Geophysical re-survey for Surinam jungle: *Eng. Mining Jour.*, v. 162, no. 4, p. 95, 1961.

An amphibian plane has been equipped with four geophysical probes for a follow-up of a previous aeromagnetometer survey of the Surinam jungle. The instruments include an electromagnetic (EM) system, a Gulf Mark III magnetometer, a sensitive scintillation counter, and an AFMag detector. With this combination of instruments it should be possible to locate magnetic, radioactive, or sulfide ore bodies. — V. S. N.

- Bullerwell, W. Geophysical investigations. See *Geophys. Abs.* 187-325.

- Griffiths, Donald Harrison, King, Roy Favell, and Wilson, Charles Douglas Vernon. Geophysical investigations in Tremadoc Bay, North Wales. See *Geophys. Abs.* 187-582.

- 187-519. LeBorgne, E[ugène]. Valeurs de la composante verticale du champ magnétique terrestre dans la Bretagne Centrale [Values of the vertical component of the geomagnetic field in central Brittany]: *Inst. Physique de Globe Paris Annales*, v. 30, p. 117-124, 1960.

A vertical magnetic survey was made, using a Schmidt balance, of an area of about 2,500 km² centered approximately on Pontivy in central Brittany in order to determine the exact nature and origin of the large local magnetic anomalies. The anomalous zone is bounded by granite and granulite massifs. In the northern part of the area surveyed the anomalies are predominantly positive and are attributed to diabases; in the southern part negative anomalies are more common and are attributed to an inverse remanent magnetization of the Brioverian schists. — D. B. V.

- 187-520. Hráč, Stanislav, Jelen, Miroslav, and Mašín, Jan. Letecké geofyzikální mapování skarnových ložisek u Županovic (Morava) [Aerial geophysical mapping of skarn deposits near Županovice (Moravia) (with English summary)]: (Czechoslovakia) Ústřed. Ústav. Geol. Vestník, v. 36, no. 1, p. 13-21, 1961.

An aeromagnetic survey was made in the vicinity of the skarn deposits near Županovice, Czechoslovakia, in a search for their possible extension. Results were compiled as a series of profiles and a map of total intensity anomalies. In addition to anomalies over the known deposits, the results showed an anomaly near Bělčovice that was subsequently found to be due to mineralized skarn. Ground magnetic surveys in the entire central part of the area, where magnetic intensity is generally higher, showed good correspondence with the airborne results; only two small anomalies, probably due to serpentines, were not recorded by the latter.

Radiometric measurements were made at the same time as the aeromagnetic survey; results are compiled in a series of profiles of gamma-ray intensity. The natural radioactivity of the rocks is higher in the central part of the area thus also suggesting a higher ore content there. — D. B. V.

- 187-521. Ștefănescu, Sabba [S.]; Stoienescu, Scarlat; Airinei, Ștefan; Botezatu, Radu; Popovici, Dorin; and Ionescu, Florian. Geophysical surveying for iron near Constanța (Rumanian People's Republic): Acad. Roumaine, Rev. Geol.-Geog., v. 5, no. 1, p. 119-132, 1961.

The discovery of a regional magnetic anomaly in the Constanța area of Rumania was followed by detailed magnetic and gravity surveys. An iron ore deposit was found to coincide with the geophysical anomalies. It is a magnetite amphibolite schist, which has a northwest strike and a dip of 90°. Several magnetic and gravity maps are given. — J. W. C.

- 187-522. Ivanov, O. D. Primeneniye magnitorazvedki pri poiskakh medno-kolchedannykh mestorozhdeniy [Use of magnetic exploration for prospecting for chalcopyrite deposits]: Razvedka i Okhrana Nedr, no. 9, p. 32-35, 1961.

Magnetic exploration in the southern Urals and Mugodzhary has proved successful for mapping hydrothermally altered zones that form aureoles around chalcopyrite deposits. A local magnetic low in an area of greenstones derived from basic effusives is an indirect indication of the presence of a chalcopyrite mineralization. The magnetic susceptibility of the host rock is decreased due to the hydrothermal alteration. Practice has shown that a copper mineralization not accompanied by a magnetic low is of little interest. — J. W. C.

- 187-523. Tikhonov, V. I., and Rivosh, L. A. Novyye dannyye o tektonicheskom stroyenii yuzhnoy Kamchatki (po rezul'tatam geologicheskikh

i aeromagnetnykh rabot) [New data on the structure of southern Kamchatka (according to the results of geologic and aeromagnetic work)]: Akad. Nauk SSSR Izv. Ser. Geol., no. 6, p. 59-69, 1961.

The results of geologic and aeromagnetic surveys of the southern part of the Kamchatka Peninsula reveal the fundamental outlines of the geologic structure and show that there is a distinct interdependence between the structure and the magnetic field on a broad scale. Sketch maps are given of the magnetic anomalies and of the essential structural features. The magnetic data suggest that on the Okhotsk Sea side of the peninsula the old metamorphic rocks dip beneath the Tertiary formations of the west Kamchatka depression. — D. B. V.

Moorcroft, E., and Dowling, D. R. Gravity and magnetic surveys over aeromagnetic anomaly—Hundred of Chandada. See Geophys. Abs. 187-335.

187-524. Christoffel, D. A. Total magnetic field measurements between New Zealand and Antarctica: *Nature*, v. 190, no. 4778, p. 776-778, 1961.

Some results of a survey of the total geomagnetic field between New Zealand and Antarctica, an area never previously surveyed magnetically, are reported. The anomalies are parallel to the bathymetric trough, are generally steep-sided, and have flattened peaks in some cases. Assuming that they are caused by dikes of magnetic material of a thickness comparable to the ocean depth, and using the method of Henderson and Zietz (see Geophys. Abs. 135-10507), the depth of the disturbing body is calculated as 3,000-4,000 fathoms below sea level (that is, a short distance below sea bottom) and the susceptibility contrast as $0.6-1.6 \times 10^{-3}$ cgs, increasing uniformly southward.

These anomalies strikingly resemble those off the California coast (Mason, see Geophys. Abs. 176-285). An explanation of their nature and direction might be that the suboceanic basalt layer has been buckled downwards owing to lateral compression, and fissures normal to the thrust direction have permitted intrusion of lavas from beneath. — D. B. V.

MICROSEISMS

187-525. Okano, Kennosuke. Observational study on microseisms, Part 1: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 44, p. 1-22, 1961; Part 2, *ibid*, no. 47, p. 1-15, 1961.

Part 1 of this paper covers essentially the same observations (Abuyama Station) as previously reported (see Geophys. Abs. 182-441, 184-511) and emphasizes the importance of using vector seismographs to study the arrival directions of microseisms by analysis of the orbital motions of the earth's particles. Part 2 discusses the results of investigations carried out at the Aso and Yura stations. The following conclusions are made: The previous inference that microseismic waves are generated near the coastline is substantiated; microseismic waves are generated most frequently where the Continental Shelf is steep; no appreciable difference in mean amplitude among waves from different directions was observed, which suggests that microseisms are generated near continental margins rather than at the coastline; microseisms generated by seasonal winter winds are of like mean period regardless of direction of arrival, but among microseisms generated by typhoons those propagated from districts having a longer distance of propagation of swells show longer periods. — V. S. N.

- 187-526. Santo, Tetsuo [Akima]. The observation of microseisms at a wave gauge station (Part 3). On the origin of microseisms: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 241-254, 1960.

A new relation is discovered between the position of a cyclone center, its rate of travel, and its central pressure when it generates the maximum microseismic disturbance at a given station. This relation can be explained by supposing an "eye of the microseismic storm" around the cyclone center, from the boundary of which the highest swells reaching the coast near the station are sent out. From microseismic observations made at a wave gauge station it is clear that the energy of swells is converted into microseisms at some steep coast. No second harmonics were found in the computed period spectrum of swells. This examination supports the standing wave theory of microseism origin. (See also Geophys. Abs. 179-351, 186-536.)—D. B. V.

- 187-527. Upton, P. S. Generation of microseismic storms in the Coral Sea: Queensland Univ. Dept. Geology Papers, v. 5, no. 7, 16 p., 1960.

The study of microseismic storms as recorded at Brisbane and Townsville, Queensland, has been carried on in some detail to gain information on the generation and propagation of these storms and to determine their use as forecasters of cyclone development and tracking aids. Microseismic storms can be correlated with either a cyclonic disturbance or with a cold front. This investigation has concentrated on the regular group microseisms associated with the tropical cyclones, and amplitude ratios have been studied to determine their use for tracking cyclones. The results firmly establish that a relationship exists between the microseism amplitude and the distance of the cyclone from the recording station and confirms that in the Coral Sea region, these microseisms are generated close to the center of the cyclone and are propagated through the earth's crust. The parameters controlling the actual generation and governing the amplitude from cyclone to cyclone were not discovered. — V. S. N.

Shimozuru, Daisuke. Volcanic micro-seisms—Discussion on the origin. See Geophys. Abs. 187-632.

RADIOACTIVITY

- 187-528. Wright, P. M., Steinberg, E. P., and Glendinin, L. E. Half-life of samarium-147: Phys. Rev., v. 123, no. 1, p. 205-208, 1961.

The half life of Sm^{147} , the isotope responsible for the natural radioactivity of that element, has been determined by specific alpha activity measurements using a liquid scintillation counting technique as $(1.05 \pm 0.02) \times 10^{11}$ yr.—D. B. V.

- 187-529. Mahadevan, C., Tilak, V. V. S. S., and Aswathanarayana, U. Radioactivity of some rock types of Andhra State, India: Geol. Soc. India Jour., v. 2, p. 11-22, 1961.

Beta activity has been determined for 37 rock samples and alpha activity for 15 rock samples from various parts of Andhra Pradesh, India. The results confirm earlier studies (see Geophys. Abs. 164-256, 167-238, 170-267, 172-207) in which the beta-activity of a rock was found to be cumulatively conditioned by its mineralogic (quartz, feldspar, and heavy minerals) and chemical (Fe_2O_3 :FeO ratio, silica, potash, alumina, and calcium oxide) constitu-

ents and by its petrogenetic history. The discrepancies in the equivalent uranium content of rocks as deduced from their beta and alpha activities, are traced to the variations in the concentration of beta-emitting K^{40} and in U:Th ratios. Results are given in tables and graphs. — V. S. N.

- 187-530. Hatuda, Zinichiro [Zin'itiro], and Nishimura, Susumu. Variations in radioactivity and chemical elements across igneous contacts [in Japanese with English abstract]: Japanese Assoc. Mineralogists, Petrologists, Econ. Geologists Jour., v. 45, no. 5, p. 163-173, 1961; supp. rept., v. 46, no. 2, p. 33-38, 1961.

Large variations in chemical composition and alpha-activity take place along traverses normal to contacts resulting from the intrusion of granitic materials into various rocks. The alpha-activity variation is found to be more conspicuous in the intrusive rocks than in the wall rocks. Spectrographic analysis indicates that across the contact of a shallow intrusive there is a conspicuous increase of volatile matter within the invading rock in the direction toward the boundary; across the contact of deeper intrusives, the distribution of volatile matter is obscure. No unusual variation in distribution of beta activity has been found. In the supplementary report a study of the rocks across the Tanakami and Koya contacts is reported; a relationship between the radioactivity type and the chemical elements or normative constituents is observed. (See also Geophys. Abs. 172-208, 178-324.) — V. S. N.

- 187-531. Starik, I. Ye., Nikolayev, D. S., Kuzelov, Yu. V., and Legin, V. K. Sootnosheniye radioaktivnosti osadkov Azovskogo i Chernogo morey [Correlation of radioactivity of Azov and Black Sea sediments]: Akad. Nauk SSSR Doklady, v. 139, no. 2, p. 456-459, 1961.

Study of the distribution of radioactive elements in sediments from the Black Sea and Sea of Azov shows that specific features of sedimentation are clearly reflected in the concentration and distribution of uranium, but scarcely expressed in variations in thorium and radium concentration. The differences can be explained by the fact that these elements behave differently in solution, depending on the physico-chemical character of the solution. — D. B. V.

- 187-532. Zolotov, A. V. Nekotoryye dannyye po issledovaniyu obraztsov pochvy i rasteniy v rayone Tunguskoy katastrofy 1908 g. [Some data from investigations of soil and plant samples in the area of the Tungus catastrophe of 1908]: Akad. Nauk SSSR Doklady, v. 140, no. 1, p. 103-106, 1961.

Investigation of the radioactivity of soils and plant materials in the area of the Tungus meteor explosion of 1908 throws no light on the relationship of the radioactivity anomaly to the catastrophe, but it is noted that some growing trees with distinct annual growth rings could be used as sensitive indicators of increases in radiation and of the time of contamination of a place by fallout from nuclear explosions. — D. B. V.

- 187-533. Israël, H[ans]. Der Diffusions-Koeffizient des Radons in Bodenluft [The diffusion coefficient of radon in soil air]: Zeitschr. Geophysik, v. 27, no. 1, p. 13-17, 1961.

The discussion provoked by E. Budde's paper on the diffusion of radon in soil air is continued. (See also Geophys. Abs. 174-314, 180-330, 184-515.) — D. B. V.

- 187-534. Srivastava, P. K., and Gupta, U. C. The use of CsI(Tl) crystal for the determination of absolute gamma emission rates: Jour. Sci. Indus. Research [India], v. 20B, no. 6, p. 243-246, 1961.

A single-channel scintillation spectrometer with a CsI(Tl) crystal as detector has been used for the determination of absolute gamma emission rates of some radio nuclides. Absolute efficiency of cylindrical cesium iodide detectors (1 in. thick and 1.5 in. diam) has been calculated for gamma ray energies from 0.1 to 5 Mev for point sources situated on the axis of the detector. Peak-to-total ratio for the detector has also been measured. — Authors' abstract

RADIOACTIVITY SURVEYING AND LOGGING

- 187-535. Balyasnyy, N. D., Kogan, R. M., Nimiforov, M. V., Renne, O. S., and Fridman, Sh. D. Radioizotopnyy analiz gornyykh porod i pochv po energeticheskomu sostavu gamma-luchey v prizemnoy atmosfere [Radioisotopic analysis of rocks and soils according to the energy spectrum of gamma-rays in the bottom layer of the atmosphere]: Akad. Nauk SSSR Doklady, v. 140, no. 4, p. 807-810, 1961.

The results of analysis of the gamma-ray spectrum observed over different types of ground (chernozem soils and a zone of hydrothermally altered igneous rocks) demonstrate the possibility of distinguishing rocks and soils by such measurements either on the ground or from planes flying several tens of meters above the ground. Results are presented in graphs and tables. In tests in the European part of the U. S. S. R., concentrations of K^{40} and Tl^{208} (ThC'') could be measured with an accuracy of 15-20 percent from a flying altitude of 25-35 m and 20-min exposure. (See also Geophys. Abs. 185-497.) — D. B. V.

- 187-536. Yakzhin, A. A. Poiski i razvedka uranovykh mestorozhdeniy [Exploration and prospecting for uranium deposits]: Moscow, Gos-geoltekhizdat, 480 p., 1961.

This is a textbook intended for university students. The topics treated are physical-chemical and radioactive properties of uranium, its uses, and methods of analysis. The genetic types of economic uranium deposits (exogenic, endogenic, and metamorphogenic) are discussed, and the uranium-bearing belts, areas, and epochs are considered. The second half of the book is devoted to exploration methods and mining processes. — A. J. S.

- 187-537. Yevstrakhin, V. A. Znachenie radiometricheskikh metodov dlya poiskov mestorozhdeniy neradioaktivnykh poleznykh iskopayemykh [Importance of radiometric methods of prospecting for deposits of nonradioactive mineral resources]: Razvedka i Okhrana Nedr, no. 10, p. 38-43, 1961.

The use of airborne, ground, and logging radioactivity surveys for detection of nonradioactive mineral deposits is discussed. Examples are given of an hydrothermal-pneumatolitic niobium deposit associated with a syenite porphyry, a pneumatolitic-hydrothermal beryllium deposit, a hydrothermal-metasomatic rare earth deposit, a niobium deposit in carbonates, a phosphorite in a region of very low relief, and an ilmenite-rutile deposit. — J. W. C.

- 187-538. Moyd, Louis, and Moyd, Pauline. Gamma ray-neutron beryllium detector as a reconnaissance tool: Am. Inst. Mining Metall. Petroleum Trans., v. 217, Tech. Paper 60H95, p. 372-376, 1960.

The Beryllometer, a field instrument for the detection of beryllium, is described and its field application discussed. The instrument can be used directly on outcrops, mine workings, dumps, or drill cores and cuttings to detect and delineate beryllium mineralization in any form. It can prove the absence of beryllium in occurrences where it has been erroneously reported and can provide rough quantitative analyses immediately in the field. The reactions are specific for beryllium. The disadvantages of the instrument, such as low effective depth penetration and bulkiness, are not serious drawbacks in comparison with its advantages. — V. S. N.

- 187-539. Zolotov, A. V., and Kukhareenko, N. K. *Sobstvennyy fon i spectral'naya chuvstvitel'nost' razryadnykh schetchikov gamma-izlucheniya* [Internal background and spectral sensitivity of radiation counters of gamma-radiation]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 29-34, 1960.

The internal radiation background of 300 counters having tungsten cathodes was measured to investigate their contamination with radioactive substances (apparently thorium). The internal radioactive background of BS-9 counters varied: 28 percent had a background of less than 50 impulses per min, 15 percent had 50-100 impulses per min, and about 40 percent had 100-150 impulses per min. The values of internal background for 75 MS-9 and AMM-9 counters with copper cathodes were 240-250 impulses per min on the average. The spectral sensitivity of radiation counters tested was found to vary within 16.0 percent of the average value (see also *Geophys. Abs.* 178-344). — A. J. S.

- 187-540. Schmidt, Robert G. Natural gamma aeroradioactivity of the Savannah River Plant area, South Carolina and Georgia: *U. S. Geol. Survey Geophys. Inv. Map GP-306*, 1961.

The natural gamma radioactivity measured at about 500 feet above ground over the Savannah River Plant area—approximately 10,000 sq mi along the central part of the border between South Carolina and Georgia—is shown on a base map by color shading to give approximate ranges of radioactivity in counts per second. A generalized geologic map of the area and an explanatory text are included.

The natural radiation level is closely related to the type of soil or rock at the surface of the ground. Locally this relation is so good that geologic contacts may be mapped from changes in radiation level. The SRP area is in two major physiographic provinces: the Piedmont, underlain by steeply inclined metamorphic and igneous rocks; and the Coastal Plain, underlain by gently dipping sedimentary rocks of Late Cretaceous to Quaternary age. The range of radioactivity is great in both provinces—250 to 2,100 counts per second in the Piedmont and 150 to 1,300 counts per second in the Coastal Plain. The radioactivity of the major rock units in each province is discussed. — V. S. N.

- 187-541. Mitchell, F. J. Radioactivity survey in eastern West Virginia: *West Virginia Geol. and Econ. Survey Rept. Inv.*, no. 21, p. 1-12, 1961.

The radioactivity survey program in West Virginia was confined to the eastern counties because the most promising rocks, the Devonian black shales, crop out in this region, and because in this area of parallel folds surveys could be conducted along the strike of the formations. The magnitude of radioactivity of the rock units in the Valley and Ridge area of Pocahontas, Greenbrier, and Pendleton Counties, and of some rock units in Jefferson and Berke-

ley Counties is shown in a table; the highest average radioactivity of 3.1 μ r per hr was found for the Chemung formation (Devonian). No economic deposits were found. — V. S. N.

- 187-542. Moxham, R[obert] M., and Eargle, D. H[oye]. Airborne radioactivity and geologic map of the Coastal Plain area, southeast Texas: U. S. Geol. Survey Geophys. Inv. Map GP-198, 1961.

The airborne radioactivity data measured at 500 feet above the ground over the central part of a surveyed area of 14,700 sq mi in the Coastal Plain of southeast Texas is compiled with the geology of the area on a mosaic of county road maps, scale 1:250,000. Radioactivity is shown by color shading to give approximate ranges in counts per second. An accompanying text discusses the general geology, radioactivity measurements, character of the gamma radiation, compilation of data, and interpretation of data.

The adjusted net count rate recorded over the various geologic formations ranges from less than 70 counts per second over the Carrizo sand in southeast Guadalupe County to about 800 counts per second over the Jackson group in western Karnes County. In the Balcones fault zone in the northwest the complex bedrock outcrop pattern is mantled in many places by fluvial terrace deposits that are the source of the measured gamma radiation and, thus, there is little correlation between survey data and geologic boundaries. South and east of this faulted area, however, more linear patterns coincident with outcrop belts of stratigraphic units become apparent. — V. S. N.

- 187-543. Schmidt, Robert G. Aeroradioactivity of the Hanford Plant area, Washington and Oregon: U. S. Geol. Survey Geophys. Inv. Map GP-307, 1961.

The natural gamma radioactivity measured at about 500 feet above ground over the Hanford Plant area, approximately 1,000 sq mi in northern Oregon and central to southern Washington, is shown on a base map by color shading to give approximate ranges of radioactivity in counts per second. The natural gamma radiation measured has a moderate range of 160-900 counts per second and is generally related to the type of rock or soil at the surface. The bedrock is Cretaceous to Recent in age and is extensively mantled by Pleistocene and Recent eolian deposits. The natural radiation of the major rock and soil types in counts per second is as follows: lake- and stream-deposited strata, 200-600; plateau basalt and loess, 400-800; loess in the eastern part, 560-700; and Recent alluvium in the western part along the Yakima River, 200-400. Measured radiation greater than 1,000 counts per second is believed to be due to activities within the Hanford AEC reservation. — V. S. N.

Hráč, Stanislav, Jelen, Miroslav, and Mašín, Jan. Aerial geophysical mapping of skarn deposits near Županovice (Moravia). See Geophys. Abs. 187-520.

- 187-544. Burke, Kevin. Tongjum uranium deposit (with Korean abstract): Korea Geol. Survey Bull., no. 4, p. 152-155, 1960.

A carborne scintillation-counter survey has led to the discovery of coatings of pitchblende and uranium secondary minerals on joints associated with a post-Cretaceous fault near Tongjum in the Republic of Korea. The occurrence, the first indication of hydrothermal uranium mineralization in Korea, is of no economic value itself but is an encouragement to further prospecting. — Author's abstract

- 187-545. Pitulej, W. Examination of radiometric anomalies between Gladstone and St. Helens: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 75-77, 1961.

In 1958 the Bureau of Mineral Resources airborne scintillograph recorded six anomalies in three areas between Gladstone and St. Helens in northeastern Tasmania. These were recently investigated on the ground by Geiger counter, but no readings were noted greater than twice background. — Author's summary

- 187-546. Hughes, T. D. Radiometric anomalies—Bicheno and Coles Bay area: Tasmania Dept. Mines Tech. Repts., no. 5 for 1960, p. 92-94, 1961.

Four anomalies detected in the Bicheno to Coles Bay area of northeastern Tasmania by an airborne scintillometer survey were shown by ground examination to be of no economic importance. — V. S. N.

- 187-547. Sukhanov, B. I., and Rukavishnikov, V. G. Neuprugoye rasseyaniye neytronov s energiyey 14 Mev na yadakh natriya, zheleza, nikelya, svintsa [Inelastic scatter of neutrons with energies of 14 Mev in nuclei of sodium, iron, nickel, and lead]: Atomnaya Energiya, v. 11, no. 4, p. 398-399, 1961.

Spectrums of inelastic scatter of neutrons are measured by the transit time method in the energy interval 0.6-4.0 Mev during bombardment of natural mixtures of isotopes of sodium, iron, nickel, and lead with an energy of 14 Mev. Results are presented on a graph and tabulated. — J. W. C.

- 187-548. Belykh, V. A., Sen'ko-Bulatnyy, I. N., Shulyat'yev, S. A., and Yakub, L. I. O vliyanii aktivatsii kremniya bystryimi neytronami pri aktivatsionnom karotazhe na mestorozhdeniyakh boksitov [On the activation effect of silicon by fast neutrons in activation logging in bauxite deposits]: Akad. Nauk SSSR Izv. Ser. Geofiz., no. 6, p. 905-909, 1961.

In activation logging of bauxites the total number of activated atoms formed by radiation from a Po-Be source according to the reaction $\text{Al}^{27}(n, \gamma)\text{Al}^{28}$ and the integral γ -field are measured. However, such a measurement may be affected by the reactions $\text{Al}^{27}(n, p)\text{Mg}^{27}$ and $\text{Si}^{28}(n, p)\text{Al}^{28}$ since the source spectrum also contains high energy neutrons of 0.5 to 11.0 Mev. The effect of these additional reactions on the results of γ -field measurements is analyzed. Activation of SiO_2 by fast neutrons affects measurements in dry bauxite boreholes but has little or no effect in boreholes where drilling mud is used. — A. J. S.

- 187-549. Fridman, Sh. D. Ob issledovaniyakh spektral'nogo sostava γ -izlucheniya gornyx porod v yestestvennom zaleganii [Regarding investigations of the spectral composition of γ -radiation of rocks in their natural occurrence]: Akad. Nauk SSSR Izv. Ser. Geofiz. no. 8, p. 1187-1197, 1960.

The possibility of spectrometric study of gamma radiation of rocks in place is discussed. The parameters characterizing the energy spectrum of gamma quanta in the approximate energy interval of 0.2-3.0 Mev are determined on the assumption that the rocks investigated do not contain a high concentration of elements of high atomic number. Nondirective (isotropic) detectors were

used. The quantity of information thus obtained is evaluated both for the source of the radiation measured and for the absorbing medium. — A. J. S.

- 187-550. Zolotov, A. V. *Raspredeleniye medlennykh neytronov v odnorodnoy srede* [Distribution of slow neutrons in a homogeneous medium], in *Yadernaya Geofizika*; Moscow, Gostoptekhizdat, p. 195-200, 1959.

The problem of the distribution of slow neutrons (thermal and epithermal) in water and water-saturated sand layers is considered with respect to the neutron, neutron-gamma, and induced activity logging methods. The correlation between thermal and epithermal neutron density in water and quartz sand of varying water saturation at various distances from the neutron emitting source was studied experimentally, and the results are presented graphically. The gauss distribution for thermal neutrons does not agree well with the experimental data, even when water content of the medium is low. — A. J. S.

- 187-551. Migunov, B. B. *Vozmozhnosti primeneniya neytronnykh metodov pri issledovanii skvazhin rudnykh mestorozhdeniy* [Feasibility of application of neutron methods to borehole investigation of ore deposits]: *Prikladnaya Geofizika*, no. 30, p. 192-197, 1961.

The neutron-neutron and induced radioactivity logging methods are investigated for possible use in prospecting for ore deposits. The effectiveness of the methods for lithium, manganese, boron, chlorine, cobalt, silver, cadmium, indium, rare elements, tantalum, tungsten, mercury, and titanium is evaluated. — A. J. S.

- 187-552. Rodermund, Carl G. *Reservoir evaluation in empty bore holes by a new logging technique*: *Kentucky Geol. Survey Spec. Pub.* 4, ser. 10, p. 7-10, 1961.

A new logging method, designed for use under empty bore-hole conditions, makes use of the unusual effects of gas on the various devices and combines them with quantitative results. The gamma-gamma density tool is used in conjunction with the neutron or induction log to provide porosity and gas saturation information. Gamma ray, caliper, and temperature surveys provide information for a consistent and valid interpretation. — V. S. N.

Per'kov, N. A. *Combination and method of geophysical logging investigations of carbonate reservoirs*. See *Geophys. Abs.* 187-204.

- 187-553. Trusheim, Ferdinand. *Über radioaktive Leithorizonte im Buntsandstein Norddeutschlands zwischen Ems und Weser* [On radioactive guide horizons in the Buntsandstein in north Germany between the Ems and Weser]: *Erdöl u. Kohle*, v. 14, no. 10, p. 797-802, 1961.

Reuter, Helmut. *Geochemische Untersuchungen einer radioaktiven Anomalie in einem norddeutschen Buntsandsteinprofil* [Geochemical investigations of a radioactive anomaly in a north German Buntsandstein Profile]: *ibid*, p. 802-803, 1961.

The radioactive anomalies in the Gray Clays of the Hardeggen Series in north Germany are of great lateral extent and can be used as a stratigraphic horizon marker. Study of cores from the Goldenstedt T 2 borehole near Vechta in south Oldenburg shows that the radioactive substance is syngenetic uranium, concentrated in centimeter-thick layers of dark dolomitic shale that was formed under paraeuxenic conditions.

The companion paper presents details of the geochemical investigation of the core samples and conditions of origin of the uranium-bearing sediments. — D. B. V.

- 187-554. Solomasov, A. I. Interpretatsiya dannykh neytronnogo gamma-metoda dlya opredeleniya vodo-neftyanogo kontakta v perforirovannykh skvazhinakh [Interpretation of data of the neutron gamma method for determining the water-oil contact in perforated wells]: *Geologiya Nefti i Gaza*, no. 6, p. 48-52, 1959.

The water-oil contact can be determined by the neutron gamma log only in uniform beds with constant composition and porosity. The Devonian terrigenous reservoirs of the Bashkir A.S.S.R. and the Tatar A. S. S. R. fulfill these requirements. The results are presented of a study of 74 producing wells in the Tuymazy field. Several types of neutron gamma curves for water-oil contacts are illustrated and analyzed. — J. W. C.

Jordan, Louise. Salt in Wellington formation, Grant County, Oklahoma. See *Geophys. Abs.* 187-210.

SEISMIC EXPLORATION

- 187-555. Bois, Pierre, Chauveau, Jean, and Hémon, Charles. Étude analogique de la déformation d'un signal sismique [Analogical study of the deformation of a seismic signal]: *Acad. Sci. [Paris] Comptes Rendus*, v. 253, no. 1, p. 165-167, 1961.

It is shown by means of a simple example how a suitable analogical model shows the reflections and transmission of a seismic signal through a layer in which velocity is not uniform. The model is as follows: two semi-infinite mediums, each with a characteristic longitudinal wave velocity and density, are separated by a layer having intermediate velocity and density that vary with depth only; a signal of known form propagates by parallel wave fronts to the boundary surfaces of the layer. The records of the signals reflected and transmitted by the bed in the overlying and underlying mediums are reproduced.

It is concluded that the reflected signals may be considerably deformed, whereas the transmitted signals show only a slight contraction and slight terminal oscillation. The bed behaves as a low-pass filter in reflection and as a high-pass filter in transmission. — D. B. V.

- 187-556. Das Gupta, S[ushil] C[handra]. On pressure waves in the coastal region: *Geofisica Pura e Appl.*, v. 48, p. 49-52, 1961.

An attempt is made to calculate the thickness of the semiliquid layer below the water column that has been postulated (Pekeris, see *Geophys. Abs.* 135-10569) to explain different aspects of pressure waves in water, including off-shore "singing" (see *Geophys. Abs.* 147-13221, 177-185, 179-114). It is found that 1,000 feet is probably a good approximation of the true value. — D. B. V.

- 187-557. Urupov, A. K. O pereschete effektivnykh skorostey v sredneplastyovyye v sluchaye dvukhsloynnoy sredy [On the conversion of effective velocities into mean formational velocities for the case of a two-layered medium]: *Prikladnaya Geofizika*, no. 30, p. 79-91, 1961.

Two methods are presented for conversion of effective seismic wave velocities into mean velocities for the sediments of the Russian platform that

overlie the main reflecting horizon. These sediments are represented by two units with respect to lithology and velocity. A halogen-carbonate or carbonate layer constitutes the lower stratum and has a velocity approximately twice that of the terrigenous upper stratum. Formulas for determination of mean velocity in terms of reduced traveltime curves by both methods are given with auxiliary formulas to account for errors caused by deviation of seismic rays in the upper layer from the vertical and also by refraction at the interface between the layers. — A. J. S.

- 187-558. Kul'chikhina, T. N. Ob usloviyakh obrazovaniya tochek vozvrata i zamknutykh petel'na godografakh otrazhennykh voln [On the conditions under which cusps and closed loops are formed on the traveltime curves of reflected waves]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 3-12, 1960.

An analytical solution of a two-dimensional kinematical problem for a circular separation boundary with a homogeneous overlying medium is discussed, and the conditions under which cusps and closed loops are formed on the traveltime curves of the waves reflected from such a boundary are demonstrated (see also Geophys. Abs. 165-339). — A. J. S.

Bolt, Bruce A. Theoretical phase velocities for a lunar seismic experiment. See Geophys. Abs. 187-83.

- 187-559. Kharaz, I. I., and Boyko, V. N. Nekotoryye rezul'taty primeneniya gruppirovaniya vzryvov v predelakh vneshney zony Predkarpatskogo progiba [Certain results of application of grouped shots in the area of the outer zone of the Cis-Carpathian depression]: Razvedochnaya i Promyslovaya Geofizika, no. 35, p. 24-29, 1960.

Results of experimental seismic exploration for testing the grouping of seismographs and shots in the outer zone of the Cis-Carpathian depression are reported. Seismograms for single shots and grouped shots are given for comparison; the total weight of the charges for each shot was 13.4 kg and the depth of explosion was 12 m. The seismograms of the grouped shots are superior to those of the single charges; they permit identification of sedimentary horizons that could not be identified by the single charge technique. The arrangement of the charges for a given base does not influence the accuracy of the seismic recording. — A. J. S.

- 187-560. Ivanov, L. I. Primeneniye seysmorazvedki dlya izucheniya pologikh platformennykh struktur Bashkirii [Use of seismic surveying for study of the gentle platform structures of Bashkiria]: Geologiya Nefti i Gaza, no. 9, p. 51-57, 1959.

Several examples are examined of the use of seismic surveying for exploration of the gentle platform structures in the Bashkir A. S. S. R. Seismic surveying has not been very effective in this area because of the experimental nature of much of its operations, inadequate apparatus, and shortage of field parties. Of the 21 structures that have been mapped by seismic surveying, 9 were first discovered by this method. The geologic conditions of the Bashkir A. S. S. R. require 75-150 km of profile on an average for an area of 100 km². The present field parties are equipped with 30- and 60-channel arrays. — J. W. C.

- 187-561. Agocs, W[illiam] B. Seismic field procedure: Jour. Mines, Metals, and Fuels [India], v. 9, no. 7, p. 28-29, 43, 1961.

A seismic field program is outlined as an example of the organization necessary to ensure a minimum cost of operation and a high yield rate from the seismic survey. — V. S. N.

- 187-562. Nagumo, Shozaburo, and Kawashima, Takeshi. On the variable area representative of the seismic record section: Japan Geol. Survey Bull., v. 11, no. 10, p. 613-618, 1960.

The method of variable area representation of the seismic record is tested by field data and its usefulness proved. — V. S. N.

- 187-563. Kunetz, G[ésa]. Essai d'analyse de traces sismiques [Attempt at analysis of seismic traces (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 317-341, 1961.

If good field records are submitted to a series of transformations that are the reverse of those leading from a velocity log to a synthetic seismogram, the result should provide more detailed and more accurate information on the variation of velocities with depth. This problem is examined theoretically. The inverse procedure involves two main steps, "deconvolution," or suppression of the effect of filtering, and "analysis," or discrimination between direct and multiple reflections. The procedure is described and discussed.

In the analysis, the rapidly increasing accumulation of errors due to noise on the record and to the approximate nature of the physical assumptions is partially accounted for by a continuous readjustment of the results. Satisfactory analysis of a rather noisy synthetic record is achieved, but the method is still too unstable to be applied to field records. An alternative method of successive approximations is outlined. — D. B. V.

- 187-564. Baranov, V[ladimir]. Énergie des vibrations et filtrage non linéaire [Energy of vibrations and nonlinear filtering (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 342-349, 1961.

In a manner somewhat analogous to gravimetry, where a strong regional anomaly conceals small local anomalies, oscillations of continuous character may obscure seismic reflections. Though variable in time, these vibrations (composed partly of noise, partly of unwanted secondary reflections) correspond to a fairly constant physical quantity, the energy of motion of the surface of the ground, which must be removed to give the actually reflected waves.

After showing that in the simplest case the density of this energy can be expressed almost exactly by a formula, it is shown how the nonlinear filtering defined by this formula can be realized. Examples are given. — D. B. V.

- 187-565. Delaplanche, J. Quelques exemples d'utilisation des films synthétiques [Some examples of utilization of synthetic seismograms (with English abstract)]: Geophys. Prosp., v. 9, no. 3, p. 427-443, 1961.

The synthetic seismogram is a geophysical instrument. Examples taken from several areas are presented in order to define this tool and to show how it may be used at all stages of exploration. In the field it can aid choice of techniques to be used, determination of volume control, and choice of filters. In interpretation of results, it can aid identification and checking off of reflections, analysis of real signals in terms of stratigraphy, study of the character of reflections on a regional scale and density of synthetic seismograms to be used, and reevaluation of information contained in old seismic records. — D. B. V.

- 187-566. Krey, Theodor, Schmidt, Gerhard, and Seelis, Karl-Heinz. Über die Möglichkeit den reflexionsseismisch erfassbaren Tiefenbereich zu erweitern [On the possibility of extending the attainable depth range of seismic reflection]: *Erdöl u. Kohle*, v. 14, no. 7, p. 521-526, 1961.

Examples are quoted to show how two of the difficulties that arise in extending the penetration of reflection shooting—the increase of energy absorption and the decrease of reflection coefficients with depth—have been met successfully in the Siegerland mining region of Germany. A third difficulty, the increased chance of multiple reflections, can be overcome by magnetic tape techniques. A fourth difficulty, that of correct depth determination when dips are steeper in the sedimentary cover than in deeper beds of interest (common in salt dome regions), can be surmounted by careful mathematical treatment of the recorded data. — D. B. V.

- 187-567. Ballakh, I. Ya. Proverka vozmozhnosti ispol'zovaniya seysmorazvedki dlya pryamykh poiskov neftegazovykh zalezhey [Test of the possibility of using seismic surveying for direct prospecting of oil and gas pools]: *Akad. Nauk SSSR Doklady*, v. 137, no. 5, p. 1174-1176, 1961.

Tests in the Mukhanov oilfield confirm the feasibility of determining oil pool limits by means of seismic reflections from oil-water interfaces, as suggested in an earlier paper by Ballakh and Mirchink (see *Geophys. Abs.* 178-355). The oil-bearing limits within three Devonian horizons in the Mukhanov field and the limits of the Okeansk and North Chernov oilfields to the north were indicated by reflection profiles. — D. B. V.

- 187-568. Levyant, V. B. Opyt provedeniya gruppovykh vzryvov v usloviyakh Stalingskoy oblasti [An experiment in conducting group shots under conditions of the Stalingrad Region]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 15-23, 1960.

The application of group shots for tracing and separation of useful waves in combination with grouping of seismographs and high frequency filters in amplifiers is discussed. The results of such an arrangement tested by the reflection method in the Stalingrad Region are given as a demonstration of the high effectiveness of such a combined technique in seismic prospecting using maximum frequencies from 70 to 100 cycles per second (see also *Geophys. Abs.* 175-357). — A. J. S.

- 187-569. Konovalov, M. M. Uproshchennoye opredeleniye popravok v godografy otrazhennykh voln za poverkhnostnyye usloviya [Simplified determination of corrections in traveltimes curves of reflected waves for surface conditions]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 61-65, 1960.

A technique for improvement in seismic reflection profile data by taking into account the topography of the low velocity zone (ZMS) is discussed. Conditions of a flat and of a rough surface of the ZMS are considered, and nomograms are given for computing corrections for the ZMS effect. — A. J. S.

- 187-570. Gurvich, I. I. O podekrannyykh otrazhennykh volnakh v seysmorazvedke [On sub-screen reflected waves in seismic surveying]: *Vyssh. Ucheb. Zavedeniye Izv., Geologiya i Razvedka*, no. 1, p. 100-116, 1961.

The problem is considered where seismic waves are reflected from boundaries of a layer located directly under a layer which has a seismic velocity higher than that of any of the layers above or immediately below. This layer is named the screening layer, because it obscures seismic waves refracted at the layers below where velocities are lower. The presence of such a screening layer has specific effects on the kinematics and dynamics of the waves reflected from the boundaries located below. These waves are named sub-screen reflected (PEO) waves. In the analysis presented the kinematics of PEO waves in horizontally and inclined layered mediums is discussed. — A. J. S.

- 187-571. Neprochnov, Yu. P. Ovybore optimal'nykh usloviy vzryva pri morskikh seysmicheskikh issledovaniyakh metodom prelomlennykh voln [On the selection of the optimum shot conditions in marine seismic investigations by the method of refracted waves]: *Razvedochnaya i Promyslovaya Geofizika*, no. 35, p. 12-15, 1960.

In seismic prospecting at sea the recurrent shocks from a deep shot carry about 40 percent of the shot's energy and produce secondary arrivals of waves on seismograms, complicating the latter. Raitt (see *Geophys. Abs.* 159-94) proposed that the quasiperiodic pulsations and shocks from the gas bubble can be used effectively if the depth of the shot is taken equal to the predominant length of the recorded seismic wave in water. The size of the charge must be selected so that the period of the bubble pulsation is equal to the prevalent period of the recorded seismic wave. A graph of optimum depth was tested in the Black Sea for 0.4 kg charges. The test showed a satisfactory agreement with the theoretical curve. — A. J. S.

Kundorf, W., and Rotter, D. On the application of the seismic self-impulse method in the investigation of dynamic effects of rock pressure. See *Geophys. Abs.* 187-593.

- 187-572. Kopf, Manfred, and Wawrzik, Martin. Schallgeschwindigkeits- und Suszeptibilitätsmessungen an Gesteinen der Trias und des Zechsteins aus dem westlich Thüringer Becken [Acoustic velocity and susceptibility measurements on rocks of the Triassic and Zechstein from the western Thuringian basin (with English and Russian summaries)]: *Geologie*, v. 10, no. 2, p. 214-230, 1961.

Velocity data on the Triassic and Zechstein rocks of the western Thuringian basin in East Germany, obtained from extensive acoustic velocity measurements made on drill cores and surface rocks using an ultrasonic pulse generator, permit calculation of the elastic wave velocities of the different stratigraphic units. As seismic reflectivity is essentially influenced by density, density is used to calculate acoustic inertias and reflection coefficients. Anisotropy due to stratification is found in sandstones with alternating clay intercalations. Borehole seismic results and velocity determinations made near boreholes are comparable to a certain extent.

Magnetic investigations show a small magnetic mineral content, particularly in the lower Keuper, but also in the lower Bunter sandstone, the "Red Röt," and the Myophoria beds; lower Keuper beds at the surface could produce local magnetic anomalies. — D. B. V.

- 187-573. World Oil. 'Suitcase seismic' records obtained from 4,000 feet: *World Oil*, v. 153, no. 4, p. 119, 1961.

A portable shallow seismic apparatus is described, and the weight and power requirements of the various components are listed. The equipment utilizes an expander which provides a preprogramed rate of grain increase on the seismogram. During the early, high amplitude arrivals, the grain of the amplifiers is low; the gain is then increased as the seismic energy decreases. — J. W. C.

- 187-574. Kharchenko, G. Ye., and Kharchenko, F. M. Malogabaritna seysmichna ustanovka dlya inzhenerno-geologichnykh to gidrogeologichnykh doslidzhen' [Small-size seismic apparatus for engineering-geological and hydrogeological investigations]: Akad. Nauk Ukrainy. RSR Dopovid, no. 9, p. 127-129, 1960.

The feasibility of designing a simplified small-size, first arrival seismograph is discussed, and its operation principle is analyzed with respect to engineering-geological and hydrogeological applications. — A. J. S.

- 187-575. Shima, Etsuzo. Note on the magnetic circuit of the moving-coil type seismometer [in Japanese with English summary]: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 545-557, 1960.

The leakage flux in the magnetic circuit of a moving-coil seismometer can be calculated most practically and simply by a method that assumes that the shape of the path of the flux approximates a circle. In this paper the magnetic circuit usually used in seismometers is investigated in detail in order to check the validity of this assumption, and to determine how to achieve a large useful flux. The theory pertinent to the design of a magnetic circuit is reviewed briefly, a model circuit is analyzed, and the magnetic circuits of 8 borehole seismometers are examined. Good agreement is found between the values calculated by the method in question and those obtained by direct measurements of the useful fluxes with the 8 seismometers, and it is concluded that the approximation can be used safely. — D. B. V.

- 187-576. Brown, M. V., Northrop, John, Frassetto, Roberto, and Grabner, L. H. Seismic refraction profiles on the continental shelf south of Bellport, Long Island, New York: Geol. Soc. America Bull., v. 72, no. 11, p. 1693-1706, 1961.

Seven reversed seismic refraction profiles were made from the Bellport Coast Guard Station to 45 miles offshore. The profiles show a thin layer of mud (compressional velocity 5,030-5,260 fps) above the wedge of unconsolidated ($v=5,700$ -6,040 fps), semiconsolidated ($v=6,370$ -6,770 fps), and consolidated ($v=7,470$ -10,700 fps) sediments that covers the basement ($v=16,300$ -18,300 fps). The thickness of the sediment layer increases seaward from 1,927 to 7,598 feet, the greatest increase coinciding with the appearance of the consolidated layer. Comparison of these results with well logs in the area indicates that the unconsolidated layer can be correlated with the Upper Cretaceous Magothy formation and the semiconsolidated layer with the Upper Cretaceous Raritan formation which overlies the gneisses and schists of the basement under Long Island. Strong evidence for a fault was found 8 miles offshore and again 19 miles offshore. — D. B. V.

- 187-577. Zumbege, James H., and Gast Paul [W.]. Geological investigations in Lake Superior: Geotimes, v. 6, no. 4, p. 10-13, 1961.

The results of investigations in the summer of 1961 of part of the Lake Superior basin by geophysical exploration, core studies, and geochemical studies are reported briefly. Continuous seismic profiles were made with a Sparker over 250 miles of traverse between Isle Royale and the Upper Peninsula of Michigan and between Isle Royal and the Minnesota shore. Preliminary study of the profiles indicates deep bedrock valleys 1,000 feet below lake level along the Minnesota shore. — V. S. N.

187-578. Offshore. Seismic survey underway off Oregon: Offshore, v. 16, no. 1, p. 19, 1961.

A seismic survey, using a gas exploder for the impulse, is underway to search for possible petroleum structures off the Oregon coast. — V. S. N.

187-579. Meador, Jimmie G. Marine seismograph and Sparker survey in the Mackenzie River, Northwest Territories, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 1153-1156, 1961.

A Sparker traverse of the Mackenzie River from Hay River to the Sans Sault Rapids, a distance of 650 miles, recorded seismic reflections from the river bottom and from 1 to 3 sub-bottom horizons to a depth of 400-1,600 feet in a continuous profile at a rate of 40 miles per day. In addition, a marine seismic survey conducted in selected areas at a rate of 70 shot locations per day mapped the geologic horizons to the basement. Both methods were used also to detail the Norman Wells reef oilfield beneath the Mackenzie River. — V. S. N.

187-580. Redpath, Bruce B. Seismic operations, in *Jacobsen-McGill Arctic research expedition to Axel Heiberg Island, Preliminary Report 1959-1960*: Montreal, McGill Univ., p. 101-107, 1961.

Preliminary results of seismic operations to determine ice depths on the White and Thompson Glaciers, and on the McGill Icecap, Axel Heiberg Island, Queen Elizabeth Islands, Canada, are reported. All depth determinations were made using reflection methods. Representative depths of ice range from 240 to 470 m. Three refraction lines were run, and the traveltime curves illustrate to some extent the effects of temperature and ablation on the velocities. — V. S. N.

187-581. Roethlisberger, Hans. Seismic refraction soundings in permafrost near Thule, Greenland, in *Geology of the Arctic*, v. 2: Internat. Symposium on Arctic geology, 1st, Calgary, Alberta, 1960, Proc., p. 970-980, 1961.

The applicability of various seismic methods for engineering purposes has been investigated in the Thule area. Special attention has been given to the refraction method in the cases where shallow ice (up to 200 feet) occurs overlying frozen ground (till), or where frozen ground (till, outwash) up to a few hundred feet thick overlies bedrock. Seismic velocities have been measured in different types of sediments of the Thule formation and in the crystalline basement rock. Very high velocities were found for all types of rock; the temperature was about -10°C , and most pores and cavities were probably filled with ice. It was discovered that for shallow soundings of a few hundred feet, the seismic methods can probably be used more elaborately in permafrost than in unfrozen material, as later pulses can be identified on the records shortly after first breaks. A negative velocity gradient in frozen ground is believed to be responsible for this. — Author's abstract

Weber, J. R. Comparison of gravitational and seismic depth determinations on the Gilman Glacier and adjoining ice-cap in northern Ellesmere Island. See *Geophys. Abs.* 187-323.

- 187-582. Griffiths, Donald Harrison, King, Roy Favell, and Wilson, Charles Douglas Vernon. Geophysical investigations in Tremadoc Bay, North Wales (with discussion): *Geol. Soc. London Quart. Jour.*, v. 117, pt. 2, p. 171-187, 1961.

Seismic refraction and proton magnetometer surveys were made of Tremadoc Bay, off North Wales, and across the coastal flats of Morfa Dyffryn to check the results of a gravity survey of North Wales that suggested Tremadoc Bay might be a Triassic basin. Seismic results indicate the presence of three layers. The top layer with maximum thickness of 1,800 feet and a velocity of 6,500 fps, is thought to be Mesozoic or Tertiary; all evidence indicates a major fault on the eastern boundary. The middle layer with maximum thickness of 6,000 feet and a velocity of 6,500 fps is probably Ordovician. The third and lowest layer is interpreted as Cambrian. A regional low over Cardigan Bay to the south points to a structural origin for the bay, although the anomaly may be due to a major granitic intrusion. — V. S. N.

- 187-583. Lliboutry, Louis, and Vivet, Roland. Épaisseurs de glace et débit solide de la Vallée Blanche supérieure (Massif du Mont-Blanc) [Ice thicknesses and solid flow of the upper Vallée Blanche (Mont Blanc Massif)]: *Acad. Sci. [Paris] Comptes Rendus*, v. 252, no. 15, p. 2274-2276, 1961.

Two refraction profiles at right angles to each other were surveyed on the upper Vallée Blanche in the Mont Blanc Massif in the Alps. The results show that the ice thickness is remarkably constant at about 145 m, plus 30 m of snow and névé.

From these results and measurements of ice flow, it is calculated that the mean net annual precipitation here is the equivalent of 270 cm of water. It was assumed in these calculations that the mass balance is actually in equilibrium, as appears to be the case. — D. B. V.

- 187-584. Dohr, G[erhard]. Über die Beobachtungen von Reflexionen aus dem tieferen Untergrunde im Rahmen routinemässiger reflexionsseismischer Messungen [On the observations of deep reflections with in the compass of routine seismic reflection surveys (with English abstract)]: *Zeitschr. Geophysik*, v. 25, no. 6, p. 280-300, 1959.

Since 1958 a number of seismic crews in Germany have been attempting to record deep reflections in routine reflection surveys as part of a program of investigation of the crust under central Europe. Results obtained to date are reviewed here. Deep reflections observed in many areas are discussed, with examples of seismograms and graphs of statistics. The recorded reflections can be referred to the Conrad discontinuity, which appears to be continuous but variable in depth under central Europe. Its surface may correlate with near-surface tectonics in some areas. Reflections from the M-discontinuity have been observed occasionally. — D. B. V.

- 187-585. Vartanov, S. P., and Kornev, V. A. Novyye dannyye o geologicheskoy stroynii severnogo Kaspiya (po rezul'tatam morskikh seysmicheskikh issledovaniy) [New data on the geology of the

north Caspian (according to the results of marine seismic study)]: Akad. Nauk SSSR Doklady, v. 136, no. 5, p. 1172-1175, 1961.

Several seismic profiles were made in the northern Caspian Sea in 1958 in conjunction with gravity and magnetic surveys. From analysis of these profiles the geologic units underlying the region have been identified, and their stratigraphic and structural relationships have been worked out. Four profiles are presented and discussed. — D. B. V.

- 187-586. Vol'vovskiy, B. S., and Vol'vovskiy, I. S. Seysmicheskiye issledovaniya po opornomu regional'nomu profilu Amu-Dar'ya (Karabekaul)-Nuratau (Koytash) [Seismic investigation along the research regional profile Amu Dar'ya (Karabekaul)-Nuratau (Koytash)]: Akad. Nauk Turkmen. SSR Izv., no. 3, p. 28-34, 1961.

The results of a seismic survey along the 320 km profile Amu Dar'ya-Nuratau are reported. The purpose of the survey was to determine subsurface structure and the depth of the Paleozoic basement. Four hundred and fifty shots of 600 kg explosive each produced on the average about 1,000 seismograms from which the nature of the deep seismic waves was determined. The three seismic stations operated during the survey are described, the types and groups of seismic waves are interpreted, and the profile is described and illustrated in a diagram. — A. J. S.

- 187-587. Tal'-Birskiy, B. B. Primeneniye seysmorazvedki v Bukharo-Khivinskoy neftegazonosnoy provintsii [Use of seismic prospecting in the Bukharo-Khivin oil-gas province]: Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy, no. 30, p. 73-78, 1961.

The geologic section and structure in the Bukharo-Khivin region of the Uzbek S. S. R. are very favorable for seismic surveying. The first seismic exploration for oil began in 1955, and 15 field parties were operating by 1959. Six seismic reflecting marker horizons are distinguished in the Meso-Cenozoic section. Each of these horizons is related to a great rhythm in sedimentation characterized by a sharp change from terrigenous to carbonate and evaporite. — J. W. C.

- 187-588. Teplitskiy, V. A. Nekotoryy rezul'taty seysmorazvedochnykh rabot v predelakh Bukharo-Gazlinskoy i Chardzhou-Pitnyakskoy zon [Some results of seismic prospecting operations within the Bukharo-Gazly and Chardzhou-Pitnyak zones]: Vses. Nauchno-Issled. Geologorazved. Neft. Inst. Trudy, no. 30, p. 79-82, 1961.

Seismic surveys during 1956-59 have yielded much information on the Bukharo-Khivin region. The configuration of the surface of the Paleozoic basement is described and illustrated by a cross section that also shows boundary velocities of refracted waves. The basement surface is characterized by several depressions and projections, which are linear in form. — J. W. C.

- 187-589. Central Water and Power Research Station Poona. Mettur Tunnel scheme. I. Seismic refraction on bed-rock: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 224-225, 1961.

Results of seismic refraction surveys in the area of the proposed Mettur Tunnel show a considerable depth of highly elastic and massive bed rock covering the site. — V. S. N.

- 187-590. Central Water and Power Research Station Poona. Geophysical investigations: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 230-248, 1961.

Results are reported briefly from seismic refraction surveys to locate two dam sites and a waste weir site (Navalpur) for the Hathmati River reservoir project, alternative weir sites on the Koyna River, a spillway site for the dam under construction on the Badua (Bihar) River, and the Navagam dam site for the Narmada River project. Electrical resistivity surveys were made also at the Navalpur weir site and electrical resistivity and magnetic surveys at the Navagam site. — V. S. N.

Kovylin, V. M. New data on the thickness of bottom sediments of the Indian Ocean. See Geophys. Abs. 187-610.

- 187-591. Sasa, Yasuo, and Izaki, Akira. Analysis and geologic interpretation of sonic survey on the western passage of Tsugaru Strait, Japan (2) [in Japanese with English abstract]: Jour. Geography [Tokyo], v. 70, no. 4 (723), p. 181-192, 1961.

The geology and geomorphology of the Tsugaru Strait are described based on an examination of rock specimens dredged from more than 2,000 localities and on further interpretation of the seismic profiles from a sonic survey (Sparker—see also Geophys. Abs. 185-563). — V. S. N.

Zverev, S. M. On the sedimentary structure in some portions of the Pacific Ocean from data on seismic reflected waves. See Geophys. Abs. 187-615.

STRENGTH AND PLASTICITY

- 187-592. Central Water and Power Research Station Poona. Modulus of elasticity of rock cores: India Ministry of Irrigation and Power Central Water and Power Research Sta. Poona Ann. Research Mem., 1960, p. 264-266, 1961.

The compressive and tensile strengths and the modulus of elasticity under compression and tension were determined for the weak tuff breccias found in the rock cores from the Koyna River weir site. The stress range adopted for the measurements of strains for the tuff breccia samples was from 0 to 200 psi for compressive and 0 to 80 psi for tensile loads. It was found that the strains within the selected range of stress followed Hooke's law. An average value for Young's modulus under compression and tension was found to be about 1.3×10^6 psi. — V. S. N.

- 187-593. Kundorf, W., and Rotter, D. Über die Anwendung der seismischer Eigenimpulsmethode bei der Erforschung dynamischer Auswirkungen des Gebirgsdruckes [On the application of the seismic self-impulse method in the investigation of dynamic effects of rock pressure (with English summary)]: Zeitschr. Geophysik, v. 27, no. 1, p. 35-47, 1961.

The present state of the method of natural seismic fields (self-impulse method) as applied to the investigation of rock stress is discussed in the light of research conducted in coal and ore mines. — D. B. V.

- 187-594. Wiebanga, W. A., and Manganwidjoyo, A. Some correlations between rock parameters, derived from Wuerker's "Annotated tables of strength and elastic properties," 1956: *Am. Inst. Mining Metall. Petroleum Engineers Trans.*, v. 217, Tech. Paper 60-AY208, p. 377-380, 1960.

Some of the correlations between rock parameters to be found by study of Wuerker's "Annotated tables of strength and elastic properties of rocks," 1956 are discussed. The empirical relations concern dry rocks of varying porosity. Curves and equations interrelating the specific gravity, compressive strength, bar velocity, and Poisson's ratio are presented. — V. S. N.

- 187-595. Hiramatsu, Yoshio, and Oka, Yukitoshi. Barodynamic experiments on the failure of rock around underground excavations: *Kyoto Univ. Eng. Research Inst. Tech. Rept.*, no. 82, v. 11, no. 5, p. 65-76, 1961.

The stress in rock around an underground excavation depends upon the topography, the nature of the ground, and the shape and size of the excavation. Barodynamic experiments are preferable to investigate the failure to be expected from earth pressures because they satisfy the law of similarity. The barodynamic experiments on the failure of ground around large excavations in the Yanahara and Kamioka mines are discussed. Models, geometrically similar to the excavations and surrounding areas, were placed in a centrifuge in such a way that the direction of centrifugal force corresponded to the direction of gravity in the prototype. In the prototype stress is caused only by gravity, while in the model it is caused by centrifugal force as well. However, since the force of gravity acting on the model is so small in relation to the centrifugal force it may be ignored; therefore, the ratio of stress at any point in a model to stress at the corresponding point in a prototype is a constant which depends upon the revolutions per minute of the centrifuge. The stress states in the two are thus similar. If model and prototype are composed of the same material, the strains are similar. It is concluded from these experiments that it is possible to foresee qualitatively what and where failure of rock will occur, but it is difficult to obtain data to predict exactly whether failure will take place or not because of the lack of homogeneity of the ground, especially around large openings. — V. S. N.

- 187-596. Snyder, James D., and Dellwig, Louis F. Plastic flowage of salt in mines at Hutchinson and Lyons, Kansas: *Kansas Geol. Survey Bull.*, no. 152, pt. 2, p. 31-46, 1961.

Plastic flowage in the pillars and floors of salt mines at Hutchinson and Lyons, Kans., is indicated by buckling, spalling, and fracturing. Data from detailed measurements of the relative sizes of pillars in newly opened rooms over an 11-month period indicate that flowage is due to the pressure of the overburden and is controlled by the percentage of salt excavated and the configuration of the excavation. Development of the structures results from spreading of the pillars by plastic flow and from movement along the lubricating underlying shale. The orientation and rate of flowage in the base, top, and middle of pillars are governed by the direction of easiest relief of stress, which, in turn, is controlled by the mining plan. — V. S. N.

- 187-597. Krausz, A. S. Etching technique to study plastic deformation of ice: *Jour. Glaciology*, v. 3, no. 30, p. 1003-1005, 1961.

A thermal-etching technique to study the underlying and governing physical phenomena in the creep behavior of ice is described. It has been found that when ice evaporates very slowly, the disturbed regions soon become visible because of the faster evaporation at these sites, that is, when ice is kept in saturated air thermal etching occurs. A few of the interesting results of application in study of grain boundary migration and of subboundary and slip line formation are described and illustrated. — V. S. N.

187-598. Kamb, W. Barclay. The glide direction in ice: *Jour. Glaciology*, v. 3, no. 30, p. 1097-1106, 1961.

The failure to detect experimentally a glide direction in the ice crystal is satisfactorily explained by assuming that the crystal glides simultaneously in three symmetry-equivalent directions with a response to the shear stress component in each direction that is the same as that observed for the crystal as a whole or for polycrystalline aggregates—the typical non-linear, power-type flow law. The 1120 direction is identified as the glide direction that accommodates the plastic properties of the ice crystal into modern concepts of crystal plasticity. — V. S. N.

Biot, M. A. Theory of folding of stratified viscoelastic media and its implications in tectonics and orogenesis. See *Geophys. Abs.* 187-251.

Biot, M. A., Odé, H., and Roever, W. L. Experimental verification of the theory of folding of stratified viscoelastic media. See *Geophys. Abs.* 187-252.

SUBMARINE GEOLOGY

187-599. Ewing, Maurice, and Landisman, Mark. Shape and structure of ocean basins, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 3-38, 1961.

The shape of the ocean basins in relation to continents, the area of the basins in relation to their depth, the pattern of transition from continent to ocean, and the form and extent of the Mid-Atlantic Ridge are discussed. The crustal structure of a typical ocean basin and the anomalous structure of the Mid-Atlantic Ridge as deduced from seismic evidence are described. The evidence from seismic waves, particularly surface waves, shows that the difference in structure between ocean basin and continent is true not only for the underlying crust but also for the mantle. Thermal, electrical, and other geophysical and geochemical evidence for the structure of the mantle are discussed briefly. It is pointed out that even the present limited knowledge about the upper mantle can lead to decisive judgments on some theories of the origin of continents and ocean basins. A bibliography of 72 items is included. — V. S. N.

187-600. Bullard, E[dward] C. Forces and processes at work in ocean basins, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 39-50, 1961.

Recent advances in our knowledge of the processes at work on the ocean floor are reviewed primarily to define the range of possible processes and to suggest further observations and experiments that may distinguish between them. The following are discussed: sedimentation in the abyssal plain and oceanic rises, and the role of turbidity currents; sedimentation along the con-

tinental shelf and possible interpretations for the observed structures; the nature and extent of submarine volcanism; and the larger tectonic pattern and its relation to the evidence for continental drift and convection currents. — V. S. N.

- 187-601. Arrhenius, Gustaf. Geological record on the ocean floor, in *Oceanography: Am. Assoc. Adv. Sci. Pub.*, no. 67, p. 129-148, 1961.

A general review is made of the wealth of information offered by the pelagic sediments for quantitative study of the past story of the solid earth, its ocean and atmosphere, and its interrelation with outer space. The characteristics of the Pacific Basin that make it particularly well suited as a recipient of representative sedimentary sequences are outlined. The sediments are discussed as a key to polar wandering, intensity changes in low-latitude atmospheric circulation, and climatic fluctuations; and the importance of study of solid particles—volcanic ash, quartz grains, cosmic spherules—in the interpretation of the record is treated. — V. S. N.

- 187-602. Carson, Rachel L. *The sea around us*: New York, Oxford University Press, 2d ed., 237 p., 1961.

Since the original edition of this book was published in 1951 many new discoveries have been made concerning the life, waters, and currents of the oceans and of the form of the ocean basins. In this 2d edition, the most important of the new findings are described in a series of notes in an appendix and are keyed to appropriate passages in the original text. The text is divided into three parts. Part 1 discusses the beginnings of the oceans in terms of earth history, the life at the surface and at depth and their interdependence, sedimentation in the ocean basins, volcanic activity and island formation, and the fluctuations of sea level throughout earth history. Part 2 discusses the motion of the sea on the surface and at depth and, part 3, the interrelation of man and the sea. — V. S. N.

- 187-603. Snodgrass, James M. *Introducing oceanography*: *ISA Jour.*, v. 8, no. 8, p. 75-79, 1961.

The science of oceanography is appraised briefly in this article, the first in a series of six. The difficulties of research work in the oceans and the generally used tools—cable-connected devices, manned and unmanned vehicles, free instruments, and buoys—are discussed. Expendable instruments seem to be one of the most promising approaches to the solution of the tremendous demands being made today for increased knowledge of the oceans; however, research on this type of device is still in the early stages, and history is only beginning for oceanography. — V. S. N.

- 187-604. Krishnan, M. S. The mid-ocean ridges: *India Nat. Inst. Sci. Proc.*, v. 26, pt. A, supp. 1, p. 195-218, 1960.

The mid-ocean ridges are located, and information on their form, structure, and origin as suggested by various authorities is discussed. The system is divided into three types: (1) The Mid-Atlantic and Mid-Indian type which Krishnan attributes to fractures developing in the crust as a result of the separation and drifting of continents; (2) the swell in the East Pacific (Easter Island-Albatross Plateau) that maybe due to comparatively mild compression of the oceanic crust resulting in slight doming without rupture or

thrusting; and (3) the Mid-Pacific ridge system that may be attributed to the formation of major shear zones in the Pacific Basin when the Atlantic and Arctic Oceans began to take shape by the more or less simultaneous movements of North America and Asia towards the Pacific basin. The Mid-Pacific Mountains may have originated as great magma intrusions along the initial shear belts; irregular pressures exerted on different parts of the Pacific Basin, especially to the north of the Mid-Pacific ridges, have broken up the oceanic crust into numerous major and minor blocks. — V. S. N.

- 187-605. Holtedahl, Olaf, and Holtedahl, Hans. On "marginal channels" along continental borders and the problem of their origin: Uppsala Univ. Geol. Inst. Bull., v. 40, p. 183-187, 1961.

Fairly recent oceanographic investigations by U.S.S.R. scientists in the sea off the Antarctic continent have shown that a very marked depression exists in the inner part of the shelf area south of Australia. This depression has an orientation parallel to the trend of the coast line and is evidently of the same type as the submarine "marginal channels" or trenches which have been described from various northern coastal regions (off Norway, W. Greenland, N. E. Labrador, N. Ellesmere Land, and others). The U.S.S.R. authors have independently arrived at the same conclusion regarding these phenomena in the southern area as the present writers have in the northern one, namely that the depressions probably indicate the existence of crustal fractures along which the land mass inside them has been uplifted in Cenozoic time. Certain problems concerning the origin of the channels are briefly discussed. — Authors' abstract

Picciotto, Edgard E. Geochemistry of radioactive elements in the ocean and the chronology of deep-sea sediments. See Geophys. Abs. 187-3.

- 187-606. Stewart, Harris B., Jr., Raff, Arthur D., and Jones, E. L. Explorer Bank—a new discovery in the Caribbean: Geol. Soc. America Bull., v. 72, no. 8, p. 1271-1274, 1961.

An "atoll-like" bank rising from nearly 1,000 fathoms to 15 fathoms about 95 miles off the Caribbean coast of Honduras was discovered and investigated by the U. S. Coast and Geodetic Survey ship, Explorer, in 1960. A towed magnetometer showed that the primarily calcareous bank has an igneous core. — D. B. V.

- 187-607. Heezen, Bruce C., Tharp, Marie, and Ewing, Maurice. The floors of the oceans. 1. The North Atlantic: Geol. Soc. America Spec. Paper 65, 122 p., 1959.

This is the text accompanying Sheet 1 of the physiographic diagram of the Atlantic Ocean, which will eventually consist of 5 sheets on a scale of about 1:5,000,000. The three major morphologic divisions are the continental margin, subdivided into three categories of provinces; the ocean basin floor, subdivided into the abyssal floor, oceanic rises, and seamount groups; and the mid-oceanic ridge, subdivided into crest and flank provinces. Each province is defined, briefly described, and illustrated with profiles and photographs of echo-sounding records. Pertinent earthquake, heat flow, magnetic, gravimetric, and other geophysical data are included in the discussions.

The boundaries of the physiographic provinces, defined solely by bottom topography, show good correlation with variations in crustal structure as determined by seismic refraction measurements and by gravity and magnetic

anomalies; they also correlate well with distribution patterns of bottom sediments. They are thus really morphotectonic provinces. — D. B. V.

- 187-608. Metcalf, W. G. Chain-17 in the Romanche Trench: *Oceanus*, v. 8, no. 1, p. 2-7, 1961.

Bathymetric and hydrographic surveys in the Romanche Trench area on the equator resulted in the location of a saddle point in the Mid-Atlantic Ridge at about long 15° W. that forms a passage for deep water. A brief preliminary discussion of the results is given. — V. S. N.

- 187-609. Emery, K[enneth] O., and Bentor, Y[aakov] K. The continental shelf of Israel: Israel Ministry of Devel., Geol. Survey Bull., no. 26, p. 25-41, 1960.

Detailed sounding profiles made across the Mediterranean continental shelf of Israel show the presence of sand, mud, and rock bottom. Some of the rocks are in the form of submerged kunkar ridges which have served as dams to cause the deposition of mud and sand on their shoreward sides. That these sediments have been derived mostly from the Nile River is indicated by a southward shoaling of the flat areas of the shelf. In contrast, the shelf edge, believed to have been eroded across rock bottom, deepens to the south, probably in response to downwarping of the earth's crust under the weight of the Nile Delta off Egypt. — Authors abstract

- 187-610. Kovylin, V. M. Novyye dannyye o moshchnosti donnykh otlozheniy Indiysskogo okeana [New data on the thickness of bottom sediments of the Indian Ocean]: *Akad. Nauk SSSR Doklady*, v. 136, no. 4, p. 924-926, 1961.

The results of seismoacoustic determinations of bottom sediment thickness at several places in the Indian Ocean are presented. Sections across the Java Trench and off Zanzibar are given. In the former, a maximum thickness of 1,450 m occurs in the Bali Basin; in the latter, thickness does not exceed 500 m and decreases gradually away from the coast. In the open ocean, bottom sediments are less than 200 m thick. The great contrast between the thickness in the coastal areas and that in the central Indian Ocean indicates that the sedimentary material is mainly land-derived. — D. B. V.

- 187-611. Bezrukov, P. L., Zatonitskiy, L. K., and Sergeyev, I. V. Gora Afanasiya Nikitina v Indiysskom okeane ("Afanasiy Nikitin Mountain" in the Indian Ocean): *Akad. Nauk SSSR Doklady*, v. 139, no. 1, p. 199-202, 1961.

A submarine mountain range in the Indian Ocean, discovered in the course of echo-sounding in December 1959 by the Vityaz expedition and named in honor of Afanasiy Nikitin, is described briefly. A bathymetric map and two profiles are given. — D. B. V.

- Starik, I. Ye., and Zharkov, A. P. Rate of sedimentation in the Indian Ocean according to data of the radiocarbon method. See *Geophys. Abs.* 187-53.

- 187-612. Raff, Arthur D. The magnetism of the ocean floor: *Sci. American*, v. 205, no. 4, p. 146-148, 150-154, 156, 1961.

A magnetometer survey of a strip of the northeast Pacific Ocean several hundred miles wide and extending 1,400 miles from Mexico to the Queen Charlotte Islands off British Columbia has revealed a north-south magnetic lineation throughout the area. The pattern is sharply broken along east-west lines from south to north by the Murray, Pioneer, and Mendocino faults. By matching magnetic "contour" lines on either side of the faults a total westward displacement of more than 700 nautical miles is found between the blocks of crust south of the Pioneer and north of the Mendocino faults. Were it not for the fault breaks some of the striations could be followed for more than 1,000 miles, and there is no reason for the lineations not to continue outside the surveyed area. Possible underlying structures that could produce this magnetic pattern are discussed; it is suggested that the present structure is the fossil record of ancient stresses, most probably from an east-west force of tension or compression. In the most probable model, the strongly positive anomalies represent ribbons of highly magnetic, volcanic basalt that flowed into channels formed by the stresses. The north-south direction of the pattern may indicate a connection with rotation. Various factors such as the effect of tidal action on rotation, of the thicker continental crust on the oceanic crust, and of earth tides are considered as sources of stress. Detailed magnetic and gravity surveys in all oceans are being planned. — V. S. N.

187-613. Bullard, Edward [C.]. The Mohole: Endeavour, v. 20, no. 80. p. 188-196, 1961.

This is a review of the background and history of the Mohole project to drill to the M-discontinuity, including results of trial drilling. Three test holes drilled near Guadalupe Island off the west coast of Mexico yielded some results of scientific value, in addition to their technological import. The sediments were found to be only 180 m thick and underlain by fresh basalt. The fact that the sediments are all Miocene eases the problem posed by the small thicknesses of unconsolidated sediments found on the ocean floor all over the world; it suggests that much of the material between the M-discontinuity and the ocean floor is composed of sediments interlayered with basalt. Temperature measurements indicate a high heat flow value (twice the average for the oceans), which confirms measurements made in the vicinity with short probes. — D. B. V.

187-614. Krause, Dale C. Geology of the sea floor east of Guadalupe Island: Deep-Sea Research, v. 8, no. 1, p. 28-38, 1961.

A gently rolling surface of very soft folded sediment lies at the anomalously shallow depth of 1,900 fathoms east of Guadalupe Island and is surrounded by deeper sea floor. The region was subject to intense activity during Tertiary time but has been deformed relatively little in comparison to the surrounding area in which large tectonic features such as volcanoes, ridges, basins, and deeps occur. It appears to have a normal oceanic crust because it has (1) a long depositional history, (2) north-south magnetic anomalies that are typical of the northeastern Pacific Ocean basin, and (3) a normal crustal thickness. — V. S. N.

187-615. Zverev, S. M. On the sedimentary structure in some portions of the Pacific Ocean from data on seismic reflected waves: Annali Geofisica, v. 14, no. 2, p. 187-196, 1961.

This is virtually the same as the paper published in Akad. Nauk SSSR Izv. Ser. Geol., no. 2, p. 80-86, 1961 (see Geophys. Abs. 185-589). — D. B. V.

VOLCANOLOGY

- 187-616. González Jenaro, R[eyna], and Foshaq, William F. The birth of Parícutin, in *Smithsonian treasury of science*, v. 2: New York, Simon and Schuster, Inc., p. 398-421, 1960.

This classic description of the birth of Parícutin Volcano in Mexico in 1943 was published originally in the *Smithsonian Report for 1946* (see also *Geophys. Abs.* 159-195, 167-287). — V. S. N.

- 187-617. A. J. G. N. Eruption of Mount Cameroon in 1959: *Overseas Geology and Mineral Resources*, v. 8, no. 2, p. 211-212, 1961.

Mount Cameroon (lat 9°14' N., long 9°10' E.) in West Africa is one of the world's largest volcanoes, rising to about 13,350 feet above sea level. Early in 1959 a series of eruptions took place, the most important of which occurred between February 8 and the end of March from three adjacent vents at a height of 8,000 feet. Mount Cameroon is composed chiefly of basalt lavas and tuffs; it is the only active member of a belt of volcanoes extending for 1,200 miles in a NNE direction from Annabon Island in the Gulf of Guinea to Lake Chad. Activity has been recorded since 1909. The most recent activity caused little damage; the largest lava flow was about 30 feet thick and had a width of nearly half a mile. — V. S. N.

- 187-618. Markhinin, Ye. K., and Alypova, O. M. O stat'ye G. S. Gorshkova "Nekotoryye voprosy teorii vulkanologii" [On S. G. Gorshkov's paper "Some questions of the theory of volcanology"]: *Akad. Nauk SSSR Izv. Ser. Geol.*, no. 5, p. 101-103, 1961.

Gorshkov's seismic evidence concerning the magma reservoir under Klyuchevskaya Volcano in Kamchatka (see *Geophys. Abs.* 176-359, 177-380) is attacked as insufficiently conclusive. Seismograms from only one earthquake were used (Japan, Nov. 17, 1953). The focal parameters of that earthquake were not determined exactly, nor was observational error estimated. In comparing records of the Klyuchi and Magadan stations Gorshkov did not take into account differences in microseismic background and differences in magnification of the instruments. Gorshkov's "retarded" transverse wave arrivals at Klyuchi station could have been later and stronger phases of the transverse waves, the weaker early arrivals having been obscured by microseisms; in some cases they could have been sS arrivals, frequently observed in records of earthquakes in the Far East.

In the stronger Japanese earthquake of June 30, 1958, when the level of microseismic noise at Klyuchi was not high, transverse wave arrivals showed no unusual features, though Gorshkov's screening effect should have been manifest. Furthermore, arrivals from south Japanese earthquakes that have been recorded at Klyuchi some 10-19 sec after P-wave arrivals have also been recorded at Magadan and Petropavlovsk, and evidently correspond to sP waves.

Thus Gorshkov's qualitative estimates of the depth and dimensions of the Klyuchevskaya magma chamber and of the elastic constants of its contents cannot by any means be considered to be established, and the far-reaching conclusions drawn from them are entirely unjustified. — D. B. V.

- 187-619. Bogoyavlenskaya, G. Ye. Vulkan Bezmyanyy na Kamchatke i yego aglomeratovyy potok [Bezmyanny Volcano on Kamchatka and its agglomerate flows]: *Akad. Nauk SSSR Lab. Vulkanologii Trudy*, no. 18, p. 3-34, 1960.

The structure and features of past eruptions of Bezmyanny Volcano are described, followed by a discussion of the agglomerate flows of March 30, 1956, and brief petrographic and chemical descriptions of its lavas and pyroclastic material. — D. B. V.

- 187-620. Svyatlovskiy, A. Ye. Ichinskiy vulkan v Sredinnom Kamchatkom khrebte (ocherk stroyeniya) [Ichinskiy Volcano in the Central Range of Kamchatka (outline of the structure)]: Akad. Nauk SSSR Lab. Vulkanologii Trudy, no. 18, p. 35-42, 1961.

The geologic setting, morphology, and structure of Ichinskiy Volcano are described briefly and its eruptive history reconstructed. It is an andesite-dacite volcano of central type, rising above an early Quaternary andesite-basalt plateau in the Central Range of the Kamchatka Peninsula. Volcanic activity in the region ceased a few hundred years ago, but there is still some fumarolic activity on the north flank of the volcano. — D. B. V.

- 187-621. Markhinin, Ye. K. Vulkanizm Kuril'skikh ostrovov [Volcanism of the Kurile Islands]: Akad. Nauk SSSR Izv. Ser. Geol., no. 6, p. 45-58, 1961.

Volcanism is extinct in the outer zone of the Kurile Island Arc, whereas it is still active in the inner zone. The outer zone is characterized by relatively high and the inner by relatively low gravity anomalies. The history of development of volcanism in the Kurile Islands is outlined.

Present volcanism is mainly the explosive type. Lavas of different composition may be erupted by different volcanoes at the same time, but in some cases a change from basic to silicic lavas in the course of time has been observed. Caldera formation has been extensive; some tens of km³ of material must have been removed from the upper crust to form these depressions. Intensive solfataric activity has given rise to sulfur deposits and alunitized zones; almost three fourths of the Kurile volcanoes are solfataric at the present time. Recent eruptions were those of Berg in the winter of 1951-52, Karpinskiy and Krenitsyna in 1952, Sarycheva in 1954 and 1956, and Zavaritskiy in 1957. The paper concludes with a brief discussion of the petrochemistry of the Quaternary volcanic rocks. — D. B. V.

- 187-622. Sekiya, H. An analysis of volcanic activity of Mt. Asama (4th paper)—An analysis of volcanic activity by the method of multiple correlation [in Japanese with English abstract]: Quart. Jour. Seismology [Tokyo], v. 25, no. 4, p. 121-130, 1961.

The relation between the eruptions of Mount Asama and the sum of earthquakes and tremors originating from the volcano and that between the eruptions and the quantity of smoke observed during the period January 1949 to October 1959 is statistically studied. Formulas are given for determining the regression plane for the anticipation of the monthly probability of eruptions (Z) from data of the same month, the anticipation of probability of eruptions in the next month (Z'), the regression plane for anticipation of the sum of kinetic energies of the explosions in a month (E) by data of the same month, and the anticipation of the sum of kinetic energies of explosion for the next month (E'). It was found that the multiple correlation coefficient of the monthly probability of eruptions is larger than that of the monthly sum of the kinetic energies of explosions. The volcanic activity anticipated by the regression plane was compared with the actual phenomena for the period January 1939 to July 1960. Results show that when Z or $E=0$ few eruptions occurred but when Z or E was larger than 0 frequent eruptions occurred. The relation between the occur-

rence of the eruptions and the calculated value of Z or E is clearer than the relation between the eruptions and the sum of volcanic earthquakes and that between the eruptions and the quantity of smoke. Preceding the great eruption of September 23, 1950, Z and E were larger than during any other rest period. — V. S. N.

- 187-623. Ito, Yoshiro. Tilting motion of the ground as related to the volcanic activity of Mt. Aso and micro-process of the tilting motion of ground and structure: Kyoto Univ. Disaster Prevention Research Inst. Bull., no. 42, p. 1-55, 1961.

The results of tiltmeter observations at two points near the active crater of Aso Volcano from 1953-59 and the conclusions reached concerning the relationship between tilting and volcanic activity are discussed. During the period two major and several minor eruptions occurred. It is concluded that the ground around Aso crater begins to rise upward several months before a large eruption; the amount of upheaval is balanced by the subsidence following the eruption—immediately in one case, several months later in another. A very large, anomalous ground tilt of 100 inches observed at Hondo Station before the eruption of June 24, 1958, was ascertained to be correct by precise leveling before and after the eruption. Therefore, it is believed that large eruptions can be forecast by tiltmeter observations at suitable points around an active crater. — V. S. N.

- 187-624. Murai, Isamu. On the mud-flows of the 1926 eruption of Volcano Tokachi-dake, Central Hokkaido, Japan: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 1, p. 55-70, 1960.

In the violently explosive eruption of Tokachi-dake Volcano on May 24, 1926, devastating mud flows were caused by collapse of the central cone and by the sudden melting of snow by burning clouds of pumice and scoria that descended the western flank of the volcano. The volume of pyroclastic deposits is estimated at about 20,000,000 m³, and the volume of mud flow deposits caused by collapse of the central cone is estimated at about 5,000,000 m³. — D. B. V.

- 187-625. Ichimura, Takeshi. Geological investigations on the Zao volcanoes. 5. — Kumano volcano: Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 2, p. 255-290, 1960.

The results of field and laboratory study of the geology of Kumano Volcano in the southern half of North Zao, Japan, are presented. Kumano is believed to have originated in the beginning of the Quaternary. Activity in historic times, recorded only since A. D. 884, has taken place mainly in the Okana crater, opened on the western flank in prehistoric times. The most violent recorded activity was an explosion of ash, lapilli, and scoria in 1895. The most recent eruption was in 1939, when several still-active fumaroles were formed. — D. B. V.

Yokoyama, Izumi. Gravity survey on the Aira caldera, Kyusyu, Japan. See Geophys. Abs. 187-333.

- 187-626. Decker, Robert W., and Hadikusomo, Djajadi. Results of the 1960 expedition to Krakatau: Jour. Geophys. Research, v. 66, no. 10, p. 3497-3511, 1961.

Activity of Anak Krakatau observed on January 12-13, 1960, consisted of explosive vulcanian-type eruptions of pyroclastics from fine ash to blocks 2

m in diameter, occurring at $\frac{1}{2}$ -10 min intervals. Four maps showing the volcano's growth since 1950 are presented. Fathometer measurements show that the 1883 caldera floor is being gradually leveled with volcanic detritus. Seismic records indicate that the eruptions begin some 200 m below sea level and churn their way to the surface. Steam generated where the magma reaches the porous pyroclastic base of Anak Krakatau is considered an important contribution to the periodic gas explosions.

Energy released in individual large explosive eruptions is estimated as 170 tons of TNT equivalent. Over 20-min increments the rate of energy release is nearly constant at 3.1×10^{13} cal, or 31,000 tons of TNT equivalent, per day. — D. B. V.

- 187-627. Gregg, D. R. Volcanoes of Tongariro National Park—A New Zealand Geological Survey Handbook: New Zealand Dept. Sci. Indus. Research Inf. Ser., no. 28, 82 p., 1960.

A popular and well-illustrated account is given of the volcanic area of the North Island of New Zealand. The Tongariro volcanoes lie at the southern end of a volcanic belt that stretches for a thousand miles across the southwest Pacific from New Zealand to Samoa. All active volcanoes, boiling springs, and geysers of New Zealand are found along this volcanic belt that extends in a northeast trending line through the center of the North Island. The major volcanoes and their eruptions are described, and the structural setting of the volcanic belt is discussed briefly. — V. S. N.

- 187-628. Verstappen, H. T. Some "volcano-tectonic" depressions of Sumatra, their origin and mode of development: Konink. Nederland. Akad. Wetensch. Proc., ser. B, v. 64, no. 3, p. 428-443, 1961.

The three "volcano-tectonic" lakes in Sumatra—Kerintji, Singkarak, and Toba—are evidently formed in a preexisting graben structure. There is no evidence of "volcano-tectonic" uparching prior to eruption, but at Toba there has been considerable young tectonic movement. This concept is the opposite of van Bemmelen's hypothesis that the depressions were formed by subsidence after eruption. The term "volcano-tectonic depression" should be abandoned, or its definition should be changed to "tectonic depression with occasional volcanic activity along faults." — D. B. V.

- Gorshkov, G. S. Petrochemistry of volcanic rocks in relation to the formation of island arcs. See Geophys. Abs. 187-256.

- 187-629. Minakami, Takeshi. Fundamental research for predicting volcanic eruptions (pt. 1): Tokyo Univ. Earthquake Research Inst. Bull., v. 38, pt. 4, p. 497-544, 1960.

The characteristics of volcanic earthquakes and crustal deformation associated with eruptions are discussed in comparison with tectonic earthquakes and deformation. Four types of volcanic earthquakes are distinguished: (1) The A-type, originating at the base of a volcano or at depths of 1-10 km, usually occurring before and in the first stage of activity. Motions cannot be distinguished from those of shallow tectonic earthquakes; P- and S-waves are characteristic. (2) B-type, with focuses limited to a radius of 1 km around the crater, shallower than the A-type; these occur in swarms and frequently are associated with vulcanian type activity, never with strombolian or hawaiian type. Surface waves predominate. (3) Explosion earthquakes, accompanying individual explosive eruptions, with an amplitude related to the magnitude of the explosion. Vibrations are similar to those of the B-type, but

magnitudes are larger. (4) Volcanic pulsation or microtremor, associated with strombolian or hawaiian type eruptions and sometimes with vulcanian, mainly surface waves.

The explosion earthquake is really a special kind of B-type earthquake; B-type earthquakes exceeding a certain magnitude are followed by explosive eruptions. In general, explosions in andesite and dacite volcanoes are preceded by a marked increase in B-type earthquakes. Also, the more frequent the B-type earthquakes, the greater the probability of large-magnitude shocks. — D. B. V.

- 187-630. Tanaka, Y[utaka], and Amano, H. Volcanic earthquake swarms of Hakoneyama and deeper earthquakes near the volcano [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 25, no. 4, p. 109-120, 1961.

Swarms of volcanic earthquakes are common in the Hakoneyama caldera, an inactive member of the Fuji volcanic zone. During the period from September 1959 to March 1960 swarms of earthquakes with epicenters several km deep took place under the Kamiyama area of the volcano. Study of seismograph records reveal that (1) the earthquakes occurred in groups each lasting over a period of 6 to 30 hr, (2) the earthquakes had great acceleration but small amplitude, (3) the relation between frequency "N" and amplitude "A" is $NA^{2.5} = \text{const}$, which indicates earthquakes medium in character between the two types of volcanic earthquakes common to Ususan, Asamayama, or Torishima, and (4) the relation between frequency "N" and the time interval of successive shocks "t" of the earthquakes, $[N]t^{1.8} = \text{const}$, shows that the Hakoneyama swarms are related to the tides of the nearby Pacific Ocean. The earthquake zones associated with the Fuji volcanic zone are discussed, and it is noted that the Hakone zone has a tendency to be active at the same time as the Northern Izu zone. Every zone tends to become active when a great earthquake occurs nearby. — V. S. N.

- 187-631. Tanaka, Y[utaka]. Relation between volcanic earthquakes and tidal phases [in Japanese with English abstract]: *Quart. Jour. Seismology* [Tokyo], v. 26, no. 1, p. 7-15, 1961.

Deformation of the earth's crust as a result of tidal pressures can cause volcanic earthquakes to occur when the epicentral region of a volcano is near the seacoast. The relationship between the frequency of volcanic earthquakes and the tidal phases was investigated for eight Japanese volcanoes located near the seacoast or forming islands. Results are illustrated in tables and graphs. — V. S. N.

- 187-632. Shimozuru, Daisuke. Volcanic micro-seisms—Discussion on the origin [in Japanese with English abstract]: *Volcanol. Soc. Japan Bull.*, ser. 2, v. 5, no. 3, p. 154-162, 1961.

An understanding of the nature and origin of volcanic microseisms (micro-tremors or harmonic tremors) is important for the prediction of volcanic eruptions, particularly those of the strombolian or hawaiian type. An analysis was made of the frequency distribution of microseisms for Kilauea, Nyiragon-go, Mihara, Aso, and Sakurajima Volcanoes from seismographs of the same frequency characteristics located not more than 600 m from the source. The results indicate that the predominating period of the microseisms becomes shorter as the volcano becomes more silicic. It is concluded that volcanic microseisms are generated by free longitudinal vibrations of a viscous lava

column with an effective length of 500 m. The natural period for each volcano, as calculated by verifying the viscosity of the column, agreed satisfactorily with the observed predominating period of volcanic microseisms. — V. S. N.

- 187-633. Ivanov, V. V. Osnovnyye stadii gidrotermal'noy deyatel'nosti vulkanov Kamchatki i Kuril'skikh ostrovov i svyazannyye s nimi tipy termal'nykh vod [The main stages of hydrothermal activity of Kamchatka and Kurile Islands volcanoes and associated types of thermal waters]: *Geokhimiya*, no. 5, p. 473-485, 1958.

Study of the fumarolic and solfataric gases and thermal waters of the Kamchatka-Kurile volcanic belt leads to the conclusion that the character and intensity of hydrothermal activity associated with contemporary volcanoes are determined not only by magma chamber activity but also by thermodynamic and hydrologic conditions in higher horizons. Fumarole gases are high-temperature volcanic exhalations that do not pass through ground water; solfataric gases are relatively low-temperature "residual" volcanic gases that are filtered through ground water. Four stages of hydrothermal activity are distinguished.

Superheated alkaline sodium chloride thermal waters are formed in abyssal high-temperature reducing environments associated with magma chambers; these carry particularly large amounts of heat and are important as sources of geothermal power, as in New Zealand and Italy (see also *Geophys. Abs.* 178-436). — D. B. V.

- 187-634. Studd, F. E. Preliminary survey of the hydrothermal field at Rabaul, New Britain: *New Zealand Jour. Geology and Geophysics*, v. 4, no. 3, p. 274-282, 1961.

Many hot springs are located around the shoreline of the breached caldera in which Rabaul is situated. Their hydrology and chemistry suggest that there is convective circulation of sea water in a zone of subsidence close to two young volcanoes. Although total heat flow is not known and there appears to be little thermoartesian pressure or hot water storage, it may be possible to exploit part of the hydrothermal field to supply Rabaul's power requirements, now furnished by expensive diesel generators. Further investigations are necessary before final assessment can be made. Geophysical surveys may guide the drilling but the final proving can come only through test drilling. — D. B. V.

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AMES W. CLARKE, DOROTHY B. VITALIANO, VIRGINIA S. NEUSCHEL, and others

GEOLOGICAL SURVEY BULLETIN 1146-E

*Abstracts of current literature
pertaining to the physics of
the solid earth and to
geophysical exploration*



UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

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Thomas B. Nolan, *Director*

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By James W. Clarke and others

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ERRATA IN BULLETIN 1146

- 185-461, p. 303 (Bull. 1146-B)
 Sixth line should read
 "lat 45° N., long 146° W."
 185-479, p. 308 (Bull. 1146-B)
 First line should read
 "Gregory, A[lan] F., Bower, Margaret E., and Morley, L. W."
 186-84, -85, -86, -87, p. 375-376 (Bull. 1146-C)
 Read "v. 2" instead of "v. 11."
 186-238, p. 417 (Bull. 1146-C)
 First line should read
 "Adams, W. M., and Carder, D[ean] S."

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